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POPULAR SCIENCE MONTHLY.

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THE DEVELOPMENT OF POLITICAL INSTITUTIONS.*

By HERBERT SPENCER.

I.—PRELIMINARY.

THOUGHT and feeling can not be completely dissociated. Each emotion has a more or less distinct framework of ideas; and each group of ideas is more or less suffused with emotion. There are, however, great differences between their degrees of combination under both of these aspects. We have some feelings which are vague from lack of intellectual definition; and others to which clear shapes are given by the associated conceptions. At one time our thoughts are distorted by the passion running through them; and at another time it is difficult to detect in them a trace of liking or disliking. Manifestly, too, in each particular case these components of the mental state may be varied in their proportions. The ideas being the same, the emotion joined with them may be greater or less; and it is a familiar truth that the correctness of the judgment formed depends, if not on the absence of emotion, still, on that balance of emotions which negatives excess of any one.

Especially is this so in matters concerning human life. There are two ways in which men's actions, individual or social, may be regarded. We may consider them as groups of phenomena to be analyzed, and the laws of their dependence ascertained; or, considering them as causing pleasures or pains, we may associate with them approbation or reprobation. Dealing with its problems intellectually, we

* The references to facts cited in this article and succeeding ones will be given when the articles reappear in their permanent shape. Allusions here and there occurring in them, to matters not before the reader, must be understood as consequent on their continuity with writings already published.

may regard conduct as always the result of certain forces; or dealing with its problems morally, and considering its outcome as in this case good and in that case bad, we may allow now admiration, and now indignation, to fill our consciousness. Obviously, it must make a great difference in our conclusions whether, as in the one case, we regard men's doings as those of alien creatures, which it merely concerns us to understand; or whether, as in the other case, we regard them as the doings of creatures like ourselves, with whose lives our own lives are bound up, and whose behavior arouses in us, directly and sympathetically, feelings of love and hate.

In "The Study of Sociology," I have described in detail the various perversions produced in men's judgments by their emotions. Examples are given showing how fears and hopes betray them into false estimates; how impatience prompts unjust condemnations; how in this case antipathy, and in that case sympathy, distorts belief. The truth that the bias of education and the bias of patriotism severally warp men's convictions, is enforced by many illustrations. And it is pointed out that the more special forms of bias—the class bias, the political bias, the theological bias—each produces a strong predisposition toward this or that view of public affairs.

Here let me emphasize the conclusion that in pursuing our sociological inquiries, and especially those on which we are now entering, we must, as much as possible, exclude whatever emotions the facts are calculated to excite, and attend solely to the interpretation of the facts. There are several groups of phenomena, in contemplating which either contempt, or disgust, or indignation, tends to arise, but must be restrained.

Instead of passing over as of no account, or else regarding as purely mischievous, the superstitions of the primitive man, we must inquire what part they play in social evolution; and must be prepared, if need be, to recognize their usefulness. Already we have seen that the belief which prompts the savage to bury valuables with the corpse and carry food to the grave has a natural genesis; that the propitiation of plants and animals and the "worship of stocks and stones" are not gratuitous absurdities; and that slaves are sacrificed at funerals in pursuance of an idea which seems rational to uninstructed intelligence. Presently we shall have to consider in what way the ghost-theory has operated politically; and, if we should find reason to conclude that it has been an indispensable aid to social evolution, we must be ready to accept the conclusion.

Knowledge of the miseries that have for countless ages been everywhere caused by the antagonisms of societies must not prevent us from recognizing the all-important part which these antagonisms have played in civilization. Shudder as we must at the cannibalism which all over the world in early days was a sequence of war; shrink

as we may from the thought of those immolations of prisoners which have, tens of thousands of times, followed battles between wild tribes ; read as we do with horror of the pyramids of heads and the whitening bones of slain peoples left by barbarian invaders ; hate, as we ought, the militant spirit which is even now among ourselves prompting base treacheries and brutal aggressions—we must not let our feelings blind us to the proofs we meet with, that intersocial conflicts have furthered the development of social structures.

Moreover, dislikes to governments of certain kinds must not prevent us from seeing their fitnesses to their circumstances. Though rejecting the common idea of glory, and declining to join soldiers and schoolboys in applying the epithet "great" to conquering despots, we detest despotism ; though we regard their sacrifices of their own peoples and of alien peoples in pursuit of universal dominion as gigantic crimes—we must yet recognize the benefits occasionally arising from the social consolidations they achieve. Neither the massacres of subjects which Roman emperors directed, nor the assassinations of relatives habitual among potentates in the East, nor the impoverishment of whole nations by the excessive exactions of tyrants, must so prejudice us as to prevent appreciation of the benefits which have, under certain conditions, resulted from the unlimited power of the supreme man. Nor must the remembrances of torturing implements, and *oubliettes*, and victims built into walls, shut out from our minds the evidence that abject submission of the weak to the strong, however unscrupulously enforced, has in some times and places been necessary.

So, too, with the associated ownership of man by man. Absolute condemnation of slavery must be withheld, even if we accept the tradition repeated by Herodotus, that to build the Great Pyramid relays of a hundred thousand slaves toiled for twenty years ; or even if we find it true that, of the serfs compelled to work at the building of St. Petersburg, three hundred thousand perished. Though aware that the unrecorded sufferings of men and women held in bondage are beyond imagination, we must, nevertheless, preserve a mental state receptive of such evidence as there may be that benefits have resulted.

In brief, trustworthy interpretations of social arrangements imply an almost passionless consciousness. Though feeling can not and ought not to be excluded from the mind when otherwise contemplating them, yet it ought to be excluded when contemplating them as natural phenomena to be understood in their causes and effects.

Maintenance of this mental attitude will be furthered by keeping before ourselves the truth that in human actions the absolutely bad may be relatively good, and the absolutely good may be relatively bad.

Though it has become a commonplace that the institutions under

which one race prospers will not answer for another, the recognition of this truth is by no means adequate. Men who have lost faith in "paper constitutions," nevertheless advocate a policy toward inferior races, implying the belief that civilized social forms can with advantage be imposed on uncivilized peoples; that the arrangements which seem to us vicious are vicious for them; and that they would benefit by institutions—domestic, industrial, or political—akin to those which we find beneficial. But acceptance of the truth that the type of a society is determined by the natures of its units, forces on us the corollary that a *régime* intrinsically of the lowest may yet be the best possible under primitive conditions.

Otherwise stating the matter, we must not substitute our developed code of conduct, which predominantly concerns private relations, for the undeveloped code of conduct which predominantly concerns public relations. Now that life is generally occupied in peaceful intercourse with fellow-citizens, ethical ideas refer chiefly to actions between man and man; but, in early stages, while the occupation of life was mainly in conflicts with adjacent societies, such ethical ideas as existed referred almost wholly to intersocial actions: men's deeds were judged by their direct bearings on tribal welfare. And since preservation of the society takes precedence of individual preservation, as being a condition to it, we must, in considering social phenomena, interpret good and bad rather in their earlier senses than in their later senses; and so must regard as relatively good that which furthers survival of the society, great as may be the suffering inflicted on individuals.

Another of our ordinary conceptions has to be much widened before we can rightly interpret political evolution. The words "civilized" and "savage" must have given to them meanings differing greatly from those which are current. That broad contrast usually drawn wholly to the advantage of the men who form advanced nations, and to the disadvantage of the men who form single groups, a better knowledge obliges us profoundly to qualify. Characters are to be found among rude peoples which compare well with those of the best among cultivated peoples. With little knowledge, and but rudimentary arts, there in some cases go virtues which might shame those among ourselves whose education and polish are of the highest.

Surviving remnants of some primitive races in India have natures in which truthfulness seems to be organic. Not only to the surrounding Hindoos, higher intellectually and relatively advanced in culture, are they in this respect far superior, but they are superior to Europeans. Of certain of these Hill peoples it is remarked in India that their assertions may always be accepted with perfect confidence; which is more than can be said of diplomatists who intentionally delude, or ministers who make false statements concerning cabinet transactions.

As having this trait may be named the Santals, of whom Hunter says, "They were the most truthful set of men I ever met"; and, again, the Sowrahs, of whom Shortt says: "A pleasing feature in their character is their complete truthfulness. They do not know how to tell a lie." Notwithstanding their sexual relations of a primitive and low type, even the Todas are described as considering "falsehood one of the worst of vices." Though Metz says that they practice dissimulation toward Europeans, yet he recognizes this as a trait consequent upon their intercourse with Europeans; and this judgment coincides with one given to me by an Indian civil servant concerning other Hill tribes, originally distinguished for their veracity, but who are rendered less veracious by contact with the whites. So rare is lying among these aboriginal races when unvitiated by the "civilized," that, of those in Bengal, Hunter singles out the Tipperahs as "the only Hill tribe in which this vice is met with."

Similarly in respect of honesty, some of those peoples classed as inferior read lessons to those classed as superior. Of the Todas just named, ignorant and degraded as they are in some respects, Harkness says, "I never saw a people, civilized or uncivilized, who seemed to have a more religious respect for the rights of *meum* and *tuum*." The Marias (Gonds), "in common with many other wild races, bear a singular character for truthfulness and honesty." Among the Khonds "the denial of a debt is a breach of this principle, which is held to be highly sinful. 'Let a man,' say they, 'give up all he has to his creditors.'" The Santal, who "never thinks of making money by a stranger," prefers to have "no dealings with his guests; but when his guests introduce the subject he deals with them as honestly as he would with his own people . . . he names the true price at first." The Lepchas "are wonderfully honest, theft being scarcely known among them." And the Bodo and Dhimáls are "honest and truthful in deed and word." Colonel Dixon dilates on the "fidelity, truth, and honesty" of the Carnatic aborigines; and they show "an extreme and almost touching devotion when put upon their honor." And Hunter asserts of the Chakmás, that "crime is rare among these primitive people. . . . Theft is almost unknown."

So it is, too, with the general virtues of these and sundry other uncivilized tribes. The Santal "possesses a happy disposition," is "sociable to a fault," "courteous," but "at the same time firm and free from cringing"; and, while the "sexes are greatly devoted to each other's society," the women are "exceedingly chaste." The Bodo and Dhimáls are "full of amiable qualities, and almost entirely free from such as are unamiable." The Lepcha, "cheerful, kind, and patient," is described by Dr. Hooker as a most "attractive companion"; and Dr. Campbell gives "an instance of the effect of a very strong sense of duty on this savage." In like manner, from accounts of certain of the Malayo-Polynesian societies, and certain of the Pap-

uan societies, may be given instances showing in high degrees sundry traits which we ordinarily associate only with a human nature that has been long subject to the discipline of civilized life and the teachings of a superior religion. One of the latest testimonies is that of Signor D'Albertis, who describes certain New Guinea people he visited (near Yule Island) as strictly honest, "very kind," "good and peaceful," and who, after disputes between villages, "are as friendly as before, bearing no animosity"; but of whom the Rev. W. G. Lawes, commenting on Signor D'Albertis's communication to the Colonial Institute, says that their good-will to the whites is being destroyed by the whites' ill-treatment of them: the usual history.

Contrariwise, in various parts of the world, men of several types yield proofs that societies relatively advanced in organization and culture may yet be barbarous in their ideas, sentiments, and usages. The Feejeeans, described by Dr. Pickering as among the most intelligent of unlettered peoples, are among the most ferocious. "Intense and vengeful malignity strongly marks the Feejeean character." Lying, treachery, theft, and murder are with them not criminal, but honorable; infanticide is immense in extent; strangling the sickly habitual; and they sometimes cut up while alive the human victims they are going to eat. Nevertheless they have a "complicated and carefully conducted political system"; well-organized military forces; elaborate fortifications; a developed agriculture with succession of crops and irrigation; a considerable division of labor; a separate distributing agency with incipient currency; and a skilled industry which builds canoes that carry three hundred men. Take again an African society, Dahomey. We find there a finished system of classes, six in number; complex governmental arrangements with officials always in pairs; an army divided into battalions, having reviews and sham-fights; prisons, police, and sumptuary laws; an agriculture which uses manure and grows a score kinds of plants; moated towns, bridges, and roads with turnpikes. Yet along with this comparatively high social development there goes what we may call organized criminality. Wars are made to get skulls with which to decorate the royal palace; hundreds of subjects are killed when the king dies; and five hundred are annually slaughtered to carry messages to the other world. Described as cruel and bloodthirsty, liars and cheats, the people are "void either of sympathy or gratitude, even in their own families," so that "not even the appearance of affection exists between husband and wife, or between parents and children." The New World, too, furnished, when it was discovered, like evidence. Having great cities of one hundred and eighty thousand houses, the Mexicans had also cannibal gods, whose idols were fed on warm, reeking, human flesh, thrust into their mouths—wars being made purposely to supply victims for them; and with skill to build stately temples, big enough for ten thousand men to dance in their courts, there went the immolation of twenty-

five hundred persons annually, in Mexico and adjacent towns alone, and of a far greater number throughout the country at large. Similarly, in the populous Central American states, sufficiently civilized to have a developed system of calculation, a regular calendar, books, maps, etc., there were like extensive sacrifices of prisoners, slaves, children, whose hearts were torn out and offered palpitating on altars, and who, in other cases, were flayed alive and their skins used as dancing-dresses by the priests.

Nor need we seek in remote regions or among alien races for proofs that there does not exist a necessary connection between the social types classed as civilized and those higher sentiments which we commonly associate with civilization. The mutilations of prisoners exhibited on Assyrian sculptures are not surpassed in cruelty by any we find among the most bloodthirsty of wild races; and Rameses II, who delighted in having himself sculptured on temple-walls throughout Egypt as holding a dozen captives by the hair, and striking off their heads at a blow, slaughtered during his conquests more human beings than a thousand chiefs of savage tribes put together. The tortures inflicted on captured enemies by red Indians are not greater than were those inflicted of old on felons by crucifixion, or on suspected rebels by sewing them up in the hides of slaughtered animals, or on heretics by smearing them over with combustibles and setting fire to them. The Damaras, described as so utterly heartless that they laugh on seeing one of their number killed by a wild beast, are not worse than were the Romans, who made such elaborate provisions for gratifying themselves by watching wholesale slaughters in their arenas. If the numbers destroyed by the hordes of Attila were not equaled by the numbers which the Roman armies destroyed at the conquest of Selucia, and by the numbers of the Jews massacred under Hadrian, it was simply because the occasions did not permit. The cruelties of Nero, Gallienus, and the rest may compare with those of Genghis and Timour; and, when we read of Caracalla that, after he had murdered twenty thousand friends of his murdered brother, his soldiers forced the Senate to place him among the gods, we are shown that in the Roman people there was a ferocity not less than that which deifies the most sanguinary chiefs among the worst of savages. Nor did Christianity greatly change matters. Throughout mediæval Europe political offenses and religious dissent brought on men carefully devised agonies equaling if not exceeding any inflicted by the most brutal of barbarians.

Startling as the truth seems, it is yet a truth to be recognized, that increase of humanity does not go on *pari passu* with civilization; but that, contrariwise, the earlier stages of civilization necessitate a relative inhumanity. Among tribes of primitive men, it is the more brutal rather than the more kindly who succeed in those conquests which effect the earliest social consolidations; and, through many subsequent

stages of social evolution, unscrupulous aggression outside of the society and cruel coercion within are the habitual concomitants of political development. The men of whom the better organized societies have been formed were at first, and long continued to be, nothing else but the stronger and more cunning savages; and even now, when freed from those influences which superficially modify their behavior, they prove themselves to be little better. If, on the one hand, we contemplate the utterly uncivilized Wood-Veddahs, who are described as "proverbially truthful and honest," "gentle and affectionate," "obeying the slightest intimation of a wish, and very grateful for attention or assistance," and of whom Pridham remarks, "What a lesson in gratitude and delicacy even a Veddah may teach!" and then if, on the other hand, we contemplate our own recent acts of international brigandage, accompanied by the slaughter of thousands who have committed no wrong against us—accompanied, too, by perfidious breaches of faith and by the killing of prisoners in cold blood—we can not but admit that, between the types of men classed as uncivilized and civilized, the differences are not necessarily of the kind commonly supposed. Whatever relation exists between moral nature and social type is not such as to imply that the social man is in all respects emotionally superior to the pre-social man.

"How is this conclusion to be reconciled with the conception of progress?" most readers will ask. "How is civilization to be justified if, as is thus implied, some of the highest of human attributes are exhibited in greater degrees by wild people who live scattered in pairs in the woods, than by the members of a vast, well-organized nation, having marvelously elaborated arts, extensive and profound knowledge, and multitudinous appliances to welfare?" The answer to this question will best be conveyed by an analogy.

As carried on throughout the animate world at large, the struggle for existence has been an indispensable means to evolution. Not simply do we see that, in the competition among individuals of the same kind, survival of the fittest has from the beginning furthered production of a higher type, but we see that to the unceasing warfare between species are mainly due both growth and organization. Without universal conflict there would have been no development of the active powers. The organs of perception and of locomotion have been little by little evolved during the interaction of pursuers and pursued. Improved limbs and senses have furnished better supplies to the viscera, and improved visceral structures have insured a better supply of aërated blood to the limbs and senses; while a higher nervous system has at each stage been required for duly coördinating the actions of these more complex structures. Among predatory animals death by starvation and among animals preyed upon death by destruction have carried off the least favorably modified individuals and varieties.

Every advance in strength, speed, agility, or sagacity in creatures of the one class, has necessitated a corresponding advance in creatures of the other class ; and without never-ending efforts to catch and to escape, with loss of life as the penalty for failure, the progress of neither could have been achieved.

Mark now, however, that while this merciless discipline of nature, "red in tooth and claw," has been essential to the evolution of sentient life, its persistence through all time with all creatures must not be inferred. The high organization evolved by and for this universal conflict is not necessarily for ever employed to like ends : the resulting power and intelligence admit of being far otherwise employed. Not for offense and defense only are the inherited structures useful, but for various other purposes ; and these various other purposes may finally become the exclusive purposes. The myriads of years of warfare which have developed the powers of all lower types of creatures have bequeathed to the highest type of creature the powers now used by him for countless objects besides those of killing and avoiding being killed. His teeth and nails are but little employed in fight ; and his mind is not ordinarily occupied in devising ways of destroying other creatures, or guarding himself from injury by them.

Similarly with social organisms. We must recognize the truth that the struggle for existence between societies has been instrumental to their evolution. Neither the consolidation and reconsolidation of small social groups into large ones, nor the organization of such compound and doubly compound groups, nor the concomitant developments of all those aids to a wider and higher life which civilization has brought, would have been possible without intertribal and international conflicts. Social coöperation is initiated by joint defense and offense ; and from the coöperation thus initiated all kinds of coöperations have arisen. Inconceivable as have been the horrors caused by this universal antagonism which, beginning with the chronic hostilities of small hordes tens of thousands of years ago, has ended in the occasional vast battles of immense nations, we must nevertheless admit that without them the world would still have been inhabited only by men of feeble types, sheltering in caves and living on wild food.

But now observe that the intersocial struggle for existence which has been indispensable in evolving societies will not necessarily play in the future a part like that which it has played in the past. Recognizing our indebtedness to war for forming great communities and developing their structures, we may yet infer that the acquired powers, available for other activities, will lose their original activities. While conceding that without these perpetual bloody strifes civilized societies could not have arisen, and that an adapted form of human nature, fierce as well as intelligent, was a needful concomitant, we may at the same time hold that, such societies having been produced, the brutality of nature in their units which was necessitated by the process, ceasing

to be necessary with the cessation of the process, will disappear. While the benefits achieved during the predatory period remain a permanent inheritance, the evils, social and individual, entailed by it will decrease and slowly die out.

Thus, then, contemplating social structures and actions from the evolution point of view, we may preserve that calmness which is needful for scientific interpretation of them, without losing our powers of feeling moral reprobation or approbation.

To these preliminary remarks respecting the mental attitude to be preserved by the student of political institutions, a few briefer ones must be added respecting the subject-matters he has to deal with.

If societies were all of the same species, and differed only in their stages of growth and structure, comparisons would disclose clearly the course of evolution; but unlikenesses of type among them, here great and there small, obscure the results of such comparisons.

Again, if each society grew and unfolded itself without the intrusion of additional factors, interpretation would be relatively easy; but the complicated processes of development are frequently recomplicated by sudden changes in the sets of factors. Now the size of the social aggregate is all at once increased or decreased by annexation or by loss of territory; and now the average character of its units is changed by the coming in of another race as conquerors or as slaves; while, as a further incident of this change, new social relations are superposed on the old. In many cases, the repeated overrunnings of societies by one another, the minglings of peoples and institutions, the breakings up and reaggregations, so destroy the continuity of normal changes as to make it extremely difficult if not impossible to draw conclusions.

Once more, change in the average mode of life pursued by a society, now increasingly warlike and now increasingly industrial, initiates metamorphoses: changed activities generate changes of structures. Hence, there have to be distinguished those progressive rearrangements which belong to the further development of one social type, from those caused by the commencing development of another social type. The lines of an organization adapted to a mode of activity that has ceased, or has been long suspended, begin to fade, and are traversed by the increasingly definite lines of an organization adapted to the mode of activity which has replaced it; and error may result from mistaking traits which belong to the one for those which belong to the other.

Hence we may infer that, out of the complex and confused evidence, only the larger truths are likely to emerge with clearness. While anticipating that certain general conclusions are to be positively

established, we may anticipate that more special ones can be alleged only as probable.

Happily, however, as we shall eventually see, those general conclusions admitting of positive establishment are the conclusions of most value for guidance.

THE SUN'S HEAT.

By Professor C. A. YOUNG,
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THERE has been a prevailing idea for many years, founded upon Brewster's fallacious experiments, that thermal, luminous, and chemical rays are fundamentally different, though coexistent in the sunbeams. This is erroneous: it is true, indeed, that rays whose vibrations are too slow to be seen produce powerful heating effects, and that those which are invisible because they are too rapid have a strong influence in determining certain chemical and physical reactions; but it is also true that the visible rays are capable of producing the same effects to a greater or less degree, and there is some reason for thinking that certain animals can see by rays to which the human retina is insensible. There is absolutely no philosophical basis for distinction between the visible and invisible radiations of the sun, except in the one point of vibration-frequency—their *pitch*, to use the analogy of sound. The expressions thermal, luminous, and chemical rays are apt to be misleading. All the waves of solar radiation are carriers of energy, and when intercepted do work, producing heat, or vision, or chemical action, according to circumstances.

If the amount of solar light is enormous as compared with terrestrial standards, the same thing is still more true of the solar heat, which admits of somewhat more accurate measurement, since we are no longer dependent on a so unsatisfactory unit as the "candle-power," and can substitute thermometers and balances for the human eye.

It is possible to intercept a beam of sunshine of known dimensions, and make it give up its radiant energy to a weighed mass of water or other substance, to measure accurately the rise of temperature produced in a given time, and from these data to calculate the whole amount of heat given off by the sun in a minute or a day.

Pouillet and Sir John Herschel seem to have been the first fairly to grasp the nature of the problem, and to investigate upon the subject in a rational manner.

Herschel's experiments were made in 1838 at the Cape of Good Hope, where he was then engaged in his astronomical work. He proceeded in this way: A small tin vessel, containing about half a pint

of water, carefully weighed, was placed on a light wooden support, touching it at only three points. This was put inside of a considerably larger cylinder, also of tinned iron; this outer cylinder having a double cover with a hole in it—the cover large enough to shade the sides of the vessel, and the hole a little less than three inches in diameter. A delicate thermometer was immersed in the water, with a sort of dasher of mica for the purpose of stirring it and keeping the temperature uniform throughout the mass. The apparatus was so placed and adjusted that the whole of the light and heat passing through the hole in the cover would fall upon the surface of the water, the sun at that time (December 31st) being within 12° of the zenith at noon.

This apparatus was placed in the sunshine and allowed to stand for ten minutes, shaded by an umbrella, and the slight rise in the temperature of the water was noted. Then the umbrella was removed and the solar rays were allowed to fall upon the water for the same length of time, and the much larger rise of temperature was noted; finally, the apparatus was again shaded and the change for ten minutes again observed. The mean between the effects in the first and last ten-minute intervals can be taken as the measure of the influence of other causes besides the sun, and, deducting this from the rise during the ten minutes' insolation, we have the effect of the simple sunshine.

Herschel's figures for his first experiment run as follows:

Rise of temperature in first ten minutes	0·25°
" " " " second ten minutes (sun)	3·90
" " " " third ten minutes	0·10

The mean of the first and third is 0·17°, and this deducted from the second gives 3·73° Fahr. as the rise of temperature produced by a sunbeam three inches in diameter, absorbed by a mass of matter equivalent to 4,638 grains of water. (We do not indicate the minutiæ of the process by which the weight of the tin vessel, thermometer, stirrer, etc., are allowed for.) Nothing more is now necessary to enable us to compute just how much heat is received by the earth in a day or a year, except, indeed, the determination of the very troublesome and somewhat uncertain correction for the absorption of heat by the earth's atmosphere; a correction deduced by means of observations made at varying heights of the sun above the horizon.

Herschel preferred to express his results in terms of melting ice, and put it in this way:

The amount of heat received on the earth's surface, with the sun in the zenith, would melt an inch thickness of ice in two hours thirteen minutes, nearly.

Since there is every reason to believe that the sun's radiation is equal in all directions, it follows that, if the sun were surrounded by a

great shell of ice, one inch thick and 186,000,000 miles in diameter, its rays would just melt the whole in the same time.

If, now, we suppose this shell to shrink in diameter, retaining, however, the same quantity of ice by increasing its thickness, it would still be melted in the same time. Let the shrinkage continue until the inner surface touches the photosphere, and it would constitute an envelope more than a mile in thickness, through which the solar fire would still thaw out its way in the same two hours and thirteen minutes; at the rate, according to Herschel's determinations, of more than forty feet a minute. Herschel continues that, if this ice were formed into a rod 45·3 miles in diameter, and darted toward the sun with the velocity of light, its advancing point would be melted off as fast as it approached, if by any means the whole of the solar rays could be concentrated upon it. Or, to put it differently, if we could build up a solid column of ice from the earth to the sun, two miles and a quarter in diameter, spanning the inconceivable abyss of ninety-three millions of miles, and if then the sun should concentrate his power upon it, it would dissolve and melt, not in an hour nor a minute, but in a single second; one swing of the pendulum, and it would be water; seven more, and it would be dissipated in vapor.

In formulating this last statement we have, however, employed, not Herschel's figures, but those resulting from later observations, which increase the solar radiation about twenty-five per cent., giving fifty feet, and not forty feet, as the thickness of the ice-crust which the sun would melt off of his own surface in a minute. An easy calculation shows that to produce this amount of heat by combustion would require the hourly burning of a layer of anthracite coal about sixteen feet (five metres) thick over the entire surface of the sun—four fifths of a ton per hour on each square foot of surface—at least eight times as much as the consumption of the most powerful blast-furnace known to art. It is equivalent to a continuous evolution of more than seven thousand horse-power on every square foot of the sun's whole area. As Sir William Thomson has shown, the sun, if it were composed of solid coal and produced its heat by combustion, would burn out in less than six thousand years.

Of this enormous outflow of heat the earth of course intercepts only a small portion, about $\frac{1}{2200000000}$. But even this minute fraction is enough to melt yearly at the equator a layer of ice something over one hundred and ten feet thick. If we choose to express it in terms of "power," we find that this is equivalent, for each square foot of surface, to more than sixty tons raised to the height of a mile; and, taking the whole surface of the earth, the *average* energy received from the sun is over fifty mile-tons yearly; or one horse-power, continuously acting, to every thirty square feet of the earth's surface. Most of this, of course, is expended merely in maintaining the earth's temperature; but a small portion, perhaps $\frac{1}{1000}$ of the whole, as estimated by

Helmholtz, is stored away by animals and vegetables, and constitutes an abundant revenue of power for the whole human race.*

If we inquire what becomes of that principal portion of the solar heat which misses the planet, and passes off into space, no certain answer can be given. Remembering, however, that space is full of isolated particles of matter (which we encounter from time to time as shooting-stars), we can see that nearer or more remotely in its course each solar ray is sure to reach a resting-place. Some have attempted to maintain that the sun sends heat only toward its planets ; that the action of radiant heat, like that of gravitation, is only between masses. But all scientific investigation so far shows that this is not the case. The energy radiated from a heated globe is found to be alike in all directions, and wholly independent of the bodies which receive it, nor is there the slightest reason to suppose the sun any way different in this respect from every other incandescent mass.

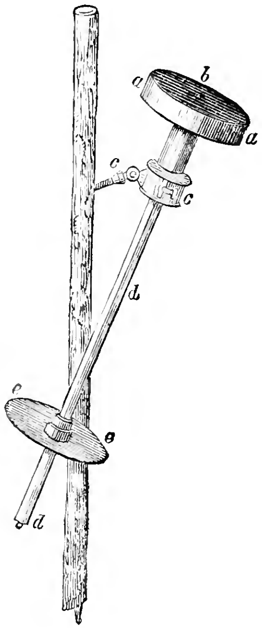


Fig. 1.

Pouillet's experiments were made about the same time as Herschel's, but with a different apparatus, though based on the same principles. He named his instrument the pyrheliometer, or measurer of solar fire. Fig. 1 represents it. The little snuffbox-like vessel, *a b*, of silver-plated copper, blackened on the upper surface, contains a weighed quantity of water, and a thermometer is immersed in it, the mercury in its stem being visible at *d*. The disk *e e* makes it easy to point the instrument squarely to the sun by directing it so that the shadow of *a* falls concentrically upon this disk. The button at the lower end is for the purpose of agitating the water in the vessel *a a*, by simply turning the whole thing on its axis in the collar *c c*. The instrument is much more convenient than Herschel's apparatus, but hardly as accurate, except under very careful manipulation.

* Several experimenters have contrived machines for the purpose of utilizing the solar heat as a source of mechanical energy, among whom Ericsson and Mouchot have been most successful. M. Pifre describes in a recent number of the "Comptes Rendus" some results from a machine of Mouchot's construction, claiming to have utilized more than eighty per cent. of the heat which falls on the mirrors of the instrument: something over twelve calories to a square metre. We do not mean, of course, that this percentage of the total solar energy appeared as mechanical power in the *engine*, but only in its *boiler*. The machine had a mirror surface of nearly one hundred square feet, and gave not quite a horse-power. It is very possible that such machines will find useful application in the rainless regions like Egypt and Peru.

Tyndall has modified it by filling the upper vessel with mercury, which is a better conductor of heat than water.

For relative measurements, as for instance a comparison of the amounts of heat received from the sun at different hours of the day, Crova employs a slightly different instrument, of which Fig. 2, copied from his paper in the "Annales de Chimie" for February, 1880, is a representation.

An exceedingly sensitive alcohol thermometer, shown separately at T, with a large bulb carefully blackened, is inclosed in a double-walled sphere B, nickel-plated on the outside. An opening in the walls of the sphere, carefully aligned with a similar opening in a double screen E, allows a beam of light to fall upon the thermometer-bulb, the beam being about two thirds the diameter of the bulb. The themometer is constructed with a supplementary reservoir, *r*, at the lower end, by means of which the end of the indicating column can be made to fall near the middle of the scale at any temperature, the object being to measure only *changes* of temperature, not absolute temperatures. The bulb and tube are so proportioned that a degree on the scale is nearly half an inch long, thus permitting great accuracy of reading.

In order, however, to determine just how much heat is required to raise the thermometer of this instrument 1°, it is necessary to compare it with one of the standard instruments, by exposing it to the sun at the same time.

This method of procedure, by which we determine the rate at which a sunbeam of given dimensions communicates heat to a measured mass of matter, is known as the *dynamic* method; it is somewhat inconvenient in requiring considerable time and a number of readings.

There is a different process for deducing the same results, which has been employed by Waterston, Ericsson, Secchi, Violle, and others, and may be called the *statical* method. It consists essentially in observing how much the sun will raise the temperature of a body, exposed to its rays, above that of the inclosure in which it is placed, this inclosure being kept at a fixed and known temperature by the circulation of water, or some such means.

Instruments based on this principle are called *actinometers*. Of these probably the most complete in its arrangements is that of Violle, described in his paper upon the mean temperature of the sun's surface, published in the "Annales de Chimie" in 1877. We give a diagram of the instrument (Fig. 3). It consists of two concentric spheres of thin metal; the outer, twenty-three centimetres in diameter, the inner, fifteen centimetres. The outer is polished on the outside, the inner is blackened on the inside. The space between the two spheres is filled with water, which is kept at a uniform temperature, either by mixing snow or ice with it, or else by a current circulated through it by means of the stopcocks *t t*. A sensitive thermometer, T, has its blackened bulb

placed in the center of the inner sphere, the stem reaching outside through a tubulure provided for the purpose. Two opposite openings, shown in the figure, allow a beam of sunlight to pass through the globes. A perforated screen at D limits its diameter so that none of it shall touch the walls of the vessel, though the thermometer-bulb is entirely covered by it. A small screen at M allows the observer to see the shadow of the thermometer-bulb, and so to perceive whether the tube through which the light enters is properly directed. If the apparatus is mounted upon what is called an equatorial stand, like a telescope, and provided with clock-work, the whole labor of observation will consist merely in reading the thermometer. The difference between its temperature and that of the water in the surrounding shell gives the necessary data for calculating the intensity of the solar radiation at the time of reading; since the heat received by the thermometer from the sun and shell together must just equal that radiated back by the thermometer-bulb to the shell, after allowing for the orifices.

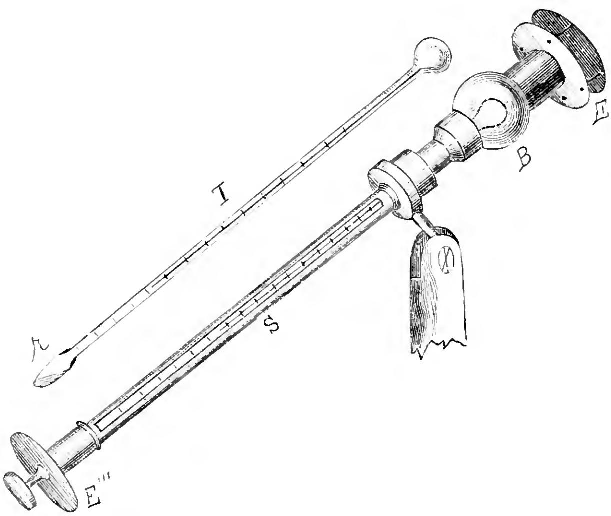


Fig. 2.—Crova's Pyrheliometer.

Violle found that at noon, on a fair day, the thermometer of this apparatus generally stood, when exposed to the sun, from 10·5° to 12·5° centigrade (i. e., 18·9° to 22·5° Fahr.) above the temperature of the shell when the latter was filled with ice-water. If it were filled with boiling water, as in some of his experiments, the difference became about 1° C. less.

The results obtained with instruments of this class of course agree very closely with those reached by the dynamic method.

It need hardly be said that the amount of heat received from the sun in a minute by a given area exposed to its radiation varies widely

according to the altitude of the sun and the condition of the air; indeed, the most difficult part of the experimental problem lies in the determination of the corrections to be applied on account of the absorption of the earth's atmosphere. It would take us too far to discuss the formulæ and methods of calculation which have been proposed. They are necessarily very complicated—those, at any, rate which are tolerably accurate in their results—because they have to take into account the meteorological conditions, especially the hygrometric state of the air. Besides this, the absorption varies greatly for radiations of different pitch; so that the violet rays, which are photographically the most active, suffer more than the green and yellow, which are most effective in the growth of plants; and these more than the red; and the red, in their turn, much more than the low-pitched, slowly vibrating waves which, though invisible, are still the chief carriers of energy, and do more to warm and vivify the earth than all the others.

Speaking loosely, it may be estimated that at the sea-level, in fair weather, neither excessively moist nor dry, about thirty per cent. of the solar radiation is absorbed when the sun is at the zenith, and at least seventy-five per cent. at the horizon. Of the rays striking the upper surface of the atmosphere, between forty-five and fifty per cent., therefore, are generally intercepted in the air, even when there are no clouds.

Of course, it does not follow that the heat absorbed in our atmosphere is lost to the earth. Far from it: the air itself becomes warmed and communicates its heat to the earth; and, since the atmosphere intercepts a large proportion of the heat which the earth would radiate into space, if not thus blanketed, the temperature of the earth is kept much higher than it would be if there were no air.

It is now generally customary to express the intensity of the solar radiation in a somewhat different way from that which has been indicated. Instead of stating how much ice would be melted in a minute by a given sunbeam, we give the number of *calories* * received per minute by one square metre exposed perpendicularly to the sun's rays at the upper surface of the atmosphere. This number is called the solar constant, and according to different experimenters ranges from Pouillet's estimate, 17·6, to that of Forbes, who found 28·2. The most reliable recent determinations by Crova and Violle set it at 23·2 and 25·4 respectively. Probably 24 is very near the truth, though there remains a considerable amount of uncertainty, since the results obtained by the same observer on different days, after all possible pains is taken with the corrections, are even more discordant than the numbers given above. A continued series of observations at some very elevated station would improve the data.

* The calory is that quantity of heat which will raise the temperature of one kilogramme of water from 0° to 1° centigrade.

Experiments with the thermopile show that the heat radiated by the solar disk varies, like the light, very considerably from the center to the edges. The first observations of this kind were made by Professor Henry, at Princeton, in 1845, and have since been repeated by many others, Secchi and Langley especially. According to Langley, the heat emitted from a point about 20″ from the limb is only one half that from the same extent of surface at the center of the disk; the diminution of heat being notably less than that of light, as shown by Vogel's observations. Langley's table runs as follows, the first column giving the distance from the center of the disk, and the second the intensity of radiation shown by the thermopile:

Distance from Center.	Heat-Radiation.
0·00	100
0·25	99
0·50	95
0·75	86
0·95	62
0·98	50

Besides this regular variation of the radiation from center to edge, Secchi in 1852 found, or thought he found, a notable difference between the radiation from the equator of the sun and that from the higher latitude, the difference being at least one sixteenth between the equator and latitude 30°. The northern hemisphere he also found to be a little hotter than the southern. Later investigators (Langley especially) have failed to find any such difference; and on the whole it seems probable that Secchi was mistaken; though this is not certain, as it would be quite unsafe to assert that the actual condition of the sun's surface may not have changed between 1852 and 1876.

In connection with the absorption of the solar atmosphere, Langley has ventured some interesting speculations. After showing that variations in the number and magnitude of sun-spots can not *directly* produce any sensible effect upon terrestrial temperatures, he calls attention to the fact that even slight changes in the depth and density of the sun's absorbing layer would make a great difference; and he raises the question whether we may not find here the explanation of glacial and carboniferous periods in the earth's history. It is quite certain that, were the envelope removed, the solar radiation would be at least doubled, and perhaps increased in a much higher ratio; while any considerable increase of its thickness would so diminish our heat-supply as to give us perpetual winter.

As yet our means of observation have not sufficed to detect with certainty any variations in the amount of heat emitted by the sun at different times. That there are such variations is almost certain, since the nuclei of sun-spots radiate much less heat as well as light than neighboring regions of the solar surface, and the faculæ more; this has been directly determined with the thermopile. The whole amount

of variation in the total heat-supply has, however, proved too small for measurement with our present instruments, and science waits anxiously for apparatus and methods of delicacy adequate to deal with the problem. We are as yet entirely uncertain whether, at the time of a sun-spot maximum, the solar radiation is more or less powerful than ordinary.

There has been a great deal of pretty vigorous discussion as to the temperature of the sun, and that the subject is a difficult one is evident enough from the wide discrepancy between the estimates of the highest authorities. For instance, Secchi originally contended for a temperature of about 18,000,000° Fahr. (though he afterward lowered his estimate to about 250,000); Ericsson puts the figure at 4,000,000

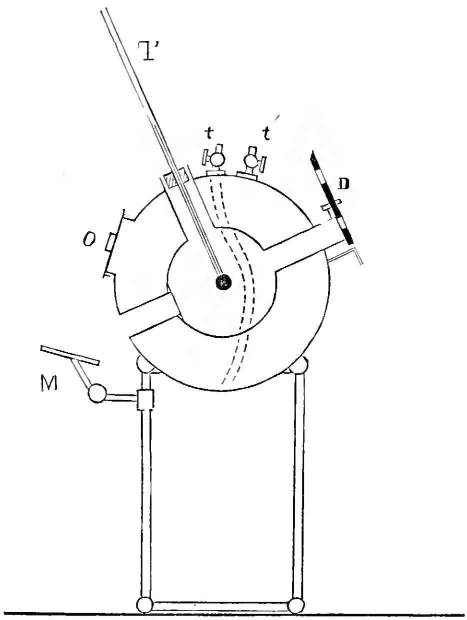


FIG. 3.—VIOLLE'S ACTINOMETER.

or 5,000,000; Zöllner, Spoerer, and Lane name temperatures ranging from 50,000° to 100,000° Fahr.; while Pouillet, Vicaire, and Deville have put it as low as between 3,000° and 10,000° Fahr. The intensest artificial heat may perhaps reach 4,000° Fahr.

The difficulty is twofold. In the first place, the sun can not properly be said to have *a* temperature, any more than the earth's atmosphere can. The temperature of different portions of the solar envelope must vary enormously, increasing fast as we descend below the surface; so that in all probability there may be a difference of thousands of degrees between the temperature at the upper surface of the photosphere and that at the sun's center, or even at the depth of a few thousand miles.

We may, however, partially evade this difficulty by substituting as the object of inquiry the sun's *effective* temperature: i. e., instead of seeking to ascertain the actual temperature of different parts of the sun's surface, we may inquire what temperature would have to be given to a uniform surface of standard radiating power (a surface covered with lampblack is generally taken as this standard) and of the same size as the sun, in order that it might emit as much heat as the sun actually does. In this way we obtain a perfectly definite object of investigation. But the problem still remains very difficult, and has obtained as yet no entirely satisfactory solution. The difficulty lies in our ignorance as to the laws which connect the temperature of a surface with the amount of heat radiated per second. So long as the temperature of the radiating body does not much exceed that of surrounding space, the heat emitted is very nearly proportional to the excess of temperature. The extremely high values of the solar temperature asserted by Secchi and Ericsson depend upon the assumption of this law (known as Newton's) of proportionality between the heat radiated and the temperature of the radiating mass; a law which direct experiment proves to be untrue as soon as the temperature rises a little. In reality, the amount of heat radiated increases much faster than the temperature.

More than forty years' ago the French physicists Dulong and Petit, by a series of elaborate experiments, deduced an empirical formula, which answered pretty satisfactorily for temperatures up to a dull-red heat. By applying this formula, Pouillet and Vicaire and others arrived at the low solar temperatures assigned by them. It is, however, evidently unsafe to apply a purely empirical formula to circumstances so far outside the range of the observations upon which it was founded, and, in fact, within a few years several experimenters, Rosetti especially, have shown that it needs modification even in the investigation of artificial temperatures, like that of the electric arc. Rosetti, from his observations, has deduced a different law of radiation, and by its application finds 10,000° Cent. or 18,000° Fahr. as the *effective temperature* of the sun; a result which, all things considered, seems more reasonable and better founded than any of the earlier estimates. He considers that this is also pretty nearly the actual temperature of the upper layers of the photosphere. The radiating power of the photospheric clouds, to be sure, can hardly be as great as that of lampblack, but on the other hand their radiation is supplemented by that of other layers, both above and below.

Besides the data as to the intensity of the solar temperature obtained by calculation from the measured emission of heat, we have also direct evidence of a very impressive sort. When heat is concentrated by a burning-glass, the temperature at the focus can not rise above that of the source of heat, the effect of the lens being simply to move the object at the focus virtually toward the sun; so that, if we neglect the

loss of heat by transmission through the glass, the temperature at the focus should be the same as that of a point placed at such a distance from the sun that the solar disk would seem just as large as the lens itself viewed from its own focus.

The most powerful lens yet constructed thus virtually transports an object at its focus to within about 250,000 miles of the sun's surface, and in this focus the most refractory substances—platinum, fire-clay, the diamond itself—are either instantly melted or dissipated in vapor. There can be no doubt that, if the sun were to come as near us as the moon, the solid earth would melt like wax.

In 1878 Professor Langley made a careful comparison between the radiation of the sun and that of the molten metal in a Bessemer "converter" when at its greatest heat. By a very ingenious arrangement he brought the solar heat and that from the metal to confront each other upon the faces of a thermopile ; and he found that, even neglecting all corrections for the loss of solar heat by transmission through the smoky atmosphere of Pittsburgh, and by the reflections which brought it to his apparatus, the sun's radiation was eighty-seven times as powerful as that from the converter, surface for surface. Had the just corrections been ascertained and applied (a matter, however, of extreme difficulty, and even impossible under the circumstances), the ratio would be increased from eighty-seven to more than one hundred certainly, and perhaps to one hundred and fifty.

As to the temperature of the metal in the converter, Professor Langley considers that it must have been above that of the fusion of platinum, because platinum wire held over the mouth of the converter just before pouring, or in the stream of metal, melts immediately. There may be some question, however, whether the melting of the wire really indicates quite so high a temperature, since fluid iron and its vapor attack platinum in something the same way as mercury and its vapor attack gold and silver. Similar conclusions as to the intensity of the solar temperature follow from investigations by Soret and others, as to the penetrating power of the sun's rays ; and from a comparison with artificial sources of heat in respect to the relative proportion of the rays of different wave-lengths in the total radiation. A body of low temperature emits an enormous proportion of slowly vibrating, invisible vibrations, while, as the temperature rises, the shorter waves become proportionally more and more abundant. Thus, in the composition of a body's radiation, we get some clew to its temperature. Hitherto all such tests concur in putting the sun's temperature high above that of any known terrestrial flame.

And now we come to questions like these : How is such a heat maintained ? How long has it lasted already—how long will it continue—are there any signs of either increase or diminution ?—questions to which, in the present state of science, only somewhat vague and unsatisfactory replies are possible.

As to progressive changes in the amount of the solar heat, it can be said, however, that there is no evidence of anything of the sort since the beginning of authentic records. There have been no such changes in the distribution of plants and animals within the last two thousand years, as must have occurred if there had been within this period any appreciable alteration in the heat received from the sun. So far as can be made out, with few and slight exceptions, the vine and olive grow just where they did in classic days, and the same is true of the cereals and the forest-trees. In the remoter past there have been undoubtedly great changes in the earth's temperature, evidenced by geological records; carboniferous epochs, when the temperature was tropical in almost arctic latitudes; and glacial periods, when our now temperate zones were cased in sheets of solid ice, as northern Greenland is at present. Even as to these changes, however, it is not yet certain whether they are to be traced to variations in the amount of heat emitted by the sun, or to changes in the earth herself or in her orbit. So far as observation goes, we can only say that the outpouring of the solar heat, amazing as it is, appears to have gone on unchanged through all the centuries of human history.

What, then, maintains the fire? It is quite certain, in the first place, that it is not a case of mere combustion. As has been said only a few pages back, it has been shown that even if the sun were made of solid coal, burning in pure oxygen, it could only last about six thousand years—it would have been nearly one third consumed since the beginning of the Christian era. Nor can the source of its heat lie simply in the cooling of its incandescent mass. Huge as it is, its temperature must have fallen more than perceptibly within a thousand years if this were the case.

Two different theories have been proposed, which are probably both true to some extent. One of them finds the chief source of the solar heat in the impact of meteoric matter, the other in the slow contraction of the sun. As to the first, it is quite certain that some of the solar heat is produced in that way; but the question is, whether the supply of meteoric matter can be sufficient to account for any great proportion of the whole. As to the second, on the other hand, there is no question as to the adequacy of the hypothesis to account for the whole supply of solar heat; but there is as yet no direct evidence whatever that the sun is really shrinking.

The basis of the meteoric theory is simply this: If a moving body be stopped, either suddenly or gradually, a quantity of heat is generated, which may be expressed, in calories, by the formula $\frac{mv^2}{850}$, in which m is the mass of the body in kilogrammes, and v its velocity in metres per second: a body weighing 850 kilogrammes and moving one metre per second would, if stopped, develop just one calory of heat—i. e., enough to heat one kilogramme of water from freezing-point to 1° centi-

grade; if it were moving 500 metres per second (about the speed of a cannon-ball), it would produce 250,000 times as much heat, or enough to raise the temperature of a mass of water equal to itself nearly 300° C. If it were moving, not 500 metres per second, but about 700,000 (approximately the velocity with which a body would fall into the sun from any planetary distance), the heat produced would be 1,400 × 1,400, or nearly 2,000,000 times as great—sufficient to bring a mass of matter many thousand times greater than itself to most vivid incandescence, and immensely more than could be produced by its complete combustion under any conceivable circumstances. With reference to this theory, Sir William Thomson has calculated the amount of heat which would be produced by each of the planets in falling into the sun from its present orbit. The results are as follows, the heat produced being expressed by giving the number of years and days through which it would maintain the sun's present expenditure of energy:

	Years.	Days.
Mercury	6	219
Venus	83	326
Earth	95	19
Mars	12	259
Jupiter	32,254	
Saturn	9,652	
Uranus	1,610	
Neptune	1,890	
Total	45,604	

That is, the collapse of all the planets upon the sun would generate sufficient heat to maintain its supply for nearly 46,000 years.

A quantity of matter equal to only about one one hundredth of the mass of the earth, falling annually upon the solar surface, would therefore maintain its radiation indefinitely. Of course, this increase of the sun would cause an acceleration of the motion of all the planets—a shortening of their periods; since, however, the mass of the sun is 330,000 times that of the earth, the yearly addition would be only one thirty-three millionth of the whole, and it would require centuries to make the effect sensible. The only question, then, is whether any such quantity of matter can be supposed to reach the sun. While it is impossible to deny this dogmatically, it on the whole seems improbable, for astronomical reasons. If so large a quantity of matter annually falls upon the solar surface, it is necessary to suppose a vastly greater quantity circulating around the sun, between it and the planet Mercury. The process by which the orbit of a meteoric body is so changed as to make it enter the solar atmosphere is a very slow one; so that only a very small proportion of the whole could be caught in any given year. But, if there were near the sun any considerable quantity of meteoric matter—anything like the mass of the earth, for

instance—it ought to produce a very observable effect upon the motions of the planet Mercury—an effect not yet detected.*

For this reason astronomers generally, while conceding that a portion, and possibly a considerable fraction, of the solar heat may be accounted for by this hypothesis, are disposed to look further for their explanation of the principal revenue of solar energy. They find it in the probable slow contraction of the sun's diameter, and the gradual liquefaction and solidification of the gaseous mass. The same total amount of heat is produced when a body moves against a resistance which brings it to rest gradually, as if it had fallen through the same distance freely and been suddenly stopped. If, then, the sun does contract, heat is necessarily produced by the process; and that in enormous quantity, since the attracting force at the solar surface is more than twenty-seven times as great as gravity at the surface of the earth, and the contracting mass is so immense.

In this process of contraction, each particle at the surface moves inward by an amount equal to the whole diminution of the solar radius, while a particle below the surface moves less, and under a diminished gravitating force; but every particle in the whole mass of the sun, excepting only that at the exact center of the globe, contributes something to the evolution of heat. To calculate the precise amount of heat developed, it would be necessary to know the law of increase of the sun's density from the surface to the center; but Helmholtz, who first suggested the hypothesis, in 1853, has shown that, under the most unfavorable suppositions, a contraction of about 250 feet a year in the sun's diameter—a mile in twenty-one years—would account for its whole annual heat-emission. This contraction is so slow that it would be quite imperceptible to observation. It would require 9,500 years to reduce the diameter a single second of arc (since 1″ equals 450 miles at the sun's distance), and nothing less would be certainly detectable.

Of course, if the contraction is more rapid than this, the mean temperature of the sun must be actually rising notwithstanding the amount of heat it is losing. Observation alone can determine whether this is so or not.

If the sun were wholly gaseous, we could assert positively that it must be growing hotter; for it is a most curious, and at first sight paradoxical, fact, first pointed out by Lane in 1870, that the temperature of a gaseous body continually rises as it contracts from loss of heat. By losing heat it contracts, but the heat generated by the contraction is more than sufficient to keep the temperature from falling.

* Leverrier considered that he had detected in the motions of Mercury an irregularity of the kind indicated, but much smaller. It was such as, according to his calculations, would be accounted for by the action of one or several planets, whose aggregate mass should be much less than that of the earth. It was on this basis that he founded his strong belief in the existence of the intra-mercurial planet, Vulcan.

A gaseous mass, losing heat by radiation, must, therefore, at the same time, grow both smaller and hotter, until the density becomes so great that the ordinary laws of gaseous expansion reach their limit, and condensation into the liquid form begins. The sun seems to have arrived at this point, if, indeed, it were ever wholly gaseous, which is questionable. At any rate, so far as we can now make out, the exterior portion—i. e., the photosphere—appears to be a shell of cloudy matter, precipitated from the vapors which make up the principal mass, and the progressive contraction, if it is indeed a fact, must result in a continual thickening of this shell and the increase of the cloud-like portion of the solar mass.

This change from the gaseous to the liquid form must also be accompanied by the liberation of an enormous quantity of heat, sufficient to materially diminish the amount of contraction needed to maintain the solar radiation.

Of course, if this theory of the source of the solar heat is correct, it follows that in time it must come to an end ; and, looking backward, we see that there must also have been a beginning : time was when there was no such solar heat as now, and the time must come when it will cease.

We do not know enough about the amount of solid and liquid matter at present in the sun, or of the nature of this matter, to calculate the future duration of the sun with great exactness, though an approximate estimate can be made. The problem is a little complicated, even on the simplest hypothesis of purely gaseous contraction, because, as the sun shrinks, the force of gravity increases, and the amount of contraction necessary to generate a given amount of heat becomes less and less ; but this difficulty is easily met by a skillful mathematician. According to Newcomb, if the sun maintains its present radiation, it will have shrunk to half its present diameter in about five millions of years, at the longest. As it must, when reduced to this size, be eight times as dense as now, it can hardly then continue to be mainly gaseous, and its temperature must have begun to fall. Newcomb's conclusion, therefore, is, that it is hardly likely that the sun can continue to give sufficient heat to support life on the earth (such life as we now are acquainted with, at least) for ten millions of years from the present time.

It is possible to compute the past of the solar history upon this hypothesis somewhat more definitely than the future. The present rate of contraction being known, and the law of variation, it becomes a purely mathematical problem to compute the dimensions of the sun at any date in the past, supposing its heat-radiation to have remained unchanged. Indeed, it is not even necessary to know anything more than the present amount of radiation and the mass of the sun, to compute how long the solar fire can have been maintained at its present intensity by the process of condensation. No conclusion of geometry

is more certain than that the contraction of the sun, from a diameter even many times larger than that of Neptune's orbit to its present dimensions, if such a contraction has actually taken place, has furnished about eighteen million times as much heat as the sun now supplies in a year; and, therefore, that the sun can not have been emitting heat at the present rate for more than that length of time, if its heat has been generated in this manner. If it could be shown that the sun has been shining as now for a longer time than that, the theory would be refuted; but, if the hypothesis be true, as it probably is in the main, we are inexorably shut up to the conclusion that the total life of the solar system, from its birth to its death, is included in some such space of time as thirty millions of years: no reasonable allowances for the fall of meteoric matter, based on what we are now able to observe, or for the development of heat by liquefaction, solidification, and chemical combination of dissociated vapors, could raise it to sixty millions.

At the same time it is, of course, impossible to assert that there has been no catastrophe in the past—no collision with some wandering star, endued, as Croll has supposed, like some of those we know of now in the heavens, with a velocity far surpassing that to be acquired by a fall, under the sun's attraction, even from infinity—producing a shock which might in a few hours, or moments even, restore the wasted energy of ages. Neither is it wholly safe to assume that there may not be ways of which we yet have no conception, by which the energy apparently lost in space may be returned, and burned-out suns and run-down systems restored; or, if not restored themselves, be made the germs and material of new ones to replace the old.

But the whole course and tendency of things, so far as science now makes out, points backward to a beginning and forward to an end. The present order of things appears to be limited in either direction by terminal catastrophes, which are veiled in clouds as yet impenetrable.

EDUCATION AS A HINDRANCE TO MANUAL OCCUPATIONS.*

By Professor SILVANUS P. THOMPSON.

THERE can not be two opinions as to the prejudicial influence exerted upon the industrial interests of Great Britain by the unsatisfactory state into which the question of apprenticeship has been gradually drifting, and out of which it has not yet begun to rise anew. Out of harmony with the necessities and conditions of the times, a relic of days long past, ere the steam-engine, or perhaps even the printing-

* Extract from an article in the September "Contemporary Review," entitled "The Apprenticeship of the Future."

press, had rendered great manufacturing industries possible, the system of apprenticeship, which has been handed down to us from our forefathers, is so strangely at variance with the most obvious principles of sound educational science, to say nothing of sound economic theory, that there is little wonder that it has fallen into discredit, and that the legal provisions under which it grew and flourished have been suffered to lapse into a dead letter. Time was when, for the most part, the skilled artisan, who was master of his trade, worked at home in his own house, assisted, it might be, by a few younger workmen or journeymen. Into his house and family he would receive one or two young lads to learn, during a seven years' engagement, the art and mystery of his craft; the master himself working and teaching them his work, feeding and clothing them, and receiving from them in return the value of the services which, as they became more apt in their work, they were able to render. The advantages of thorough training by the continuous care of the master were unquestionably proved by the universal adoption of the system. The ancient trade guilds grew and acquired their legal status upon this usage as their very foundation, and a seven years' apprenticeship formed the one necessary qualification for the possession of the right to exercise the following of any occupation or employment, art or craft, recognized among the handicrafts of the time. With the extension of trade and the wider use of machinery the number and power of the adult employed workmen increased, and with their increase of power came a jealousy, on the one hand, toward the masters; on the other, toward the apprentices, who were regarded as cheapening labor when employed in too great numbers. The conflict which arose between employer and employed gradually merged into one between capital and labor. By dint of strikes the workmen at last prevailed, and, in attempting to bring about a limitation in the amount of apprenticeship labor, brought about a result of quite another kind, and one far more disastrous than the evil sought to be remedied—the destruction of all the best and most important features of apprenticeship. Other issues aided in the accomplishment of the course thus entered on. Mr. George Howell has so well delineated the outlines of the change, that the transcription of a few of his words will suffice to complete the tale. "But a change was coming o'er the spirit of the dream: another day was dawning fraught with still greater issues to the journeymen, for, instead of the old system of master and craftsmen, there grew up quite another kind of mastership and of hiring. The master had already begun to be less the craftsman and more of the employer. Capital was fast becoming the great motive power. Streams were first utilized, then steam; complicated machinery was being substituted for hand-labor in many of the growing industries of the time; the master no longer worked at the trade himself, he directed and found the capital. The number of persons employed was also greatly augmented; instead of the old fealty be-

tween master and men there came estrangement more and more, until sometimes the workpeople scarcely ever saw their veritable employer. Under these circumstances the conditions of apprenticeship were completely changed, not suddenly, but gradually, until the apprentice became merely the boy worker, with less wages but more solemn engagements than a journeyman. The master to whom he was bound no longer taught him his trade; he was, so to speak, pitchforked into the workshop to pick up his trade as best he could, or to learn it from the many journeymen who were there employed. It was no one's duty to teach him; there was no pay and no responsibility."

The present state of British commerce brings home the conviction that it is no idle cry that has sounded ever and anon in our ears, warning us of the deterioration in the quality of our manufactures and in the average caliber of our skilled artisans. International exhibitions have from time to time afforded the means of drawing comparisons between the work of other nations and our own work; comparisons by no means always in our favor, often the reverse. Apprenticeship, with its wholesome rules, having decayed in everything but form, the lads who enter the shops are never properly instructed, but are made the drudges of the older workmen. What wonder that they acquire habits of idleness and carelessness that not only pursue them through the whole of their work, but, worse than this, corrupt and undermine their morals? What wonder that their manipulation is but half acquired, or that the methods and devices they learn to apply are those of half a century ago; ancient relics of prejudice and unscientific "rules of thumb," handed down by the tradition of the shops, a veritable survival of the unfittest? Without the shadow of a doubt the truth that there is—and alas, that there is—much truth in the outcry concerning the inferiority of training and capacity of the British artisan, may be very largely imputed to the relaxation and degeneration of the old system of apprenticeship; for, with all its faults, it did at least provide that a skilled master should become personally responsible for the training of the apprentice in his craft. In that famous codicil to his will wherein Benjamin Franklin devised so many thoughtful legacies to promote the well-being of the land and city of his adoption, he wrote—and we must remember how intimate and many-sided was his acquaintance with the condition of labor in his day—these ever-memorable words: "*I have considered that, among citizens, good apprentices are most likely to make good citizens.*" If this be true, seeing how rare a good apprentice is in the present day, the aphorism instilled into our ears as schoolboys, *Boni cives rari* (good citizens are scarce), threatens to receive a weighty comment from the experience of the nineteenth century! Be this as it may, a very little consideration will show how real is the crisis to be faced, and how irrevocably of the past the apprenticeship of the past is.

What, then, must be done? "Apprenticeship is absolutely neces-

sary for the purpose of acquiring a practical knowledge of a trade; without this there can be no guarantee for good and efficient workmanship." Such is the dictum of one who speaks with authority from the point of view of labor, and the sentiment is the expression of that which all admit. Better education of the children—such, in fact, as is contemplated by the provisions of the Elementary Education Act of 1870—may, it is hoped, quicken the intelligence ere the age is reached at which apprenticeship begins: but will it do more? Nay, have we not indeed some reason rather to look askance at the work of the school boards, and the scheme of education which they offer to our juvenile artisan population? *Cæteris paribus*, the better educated our artisans are, the better workmen will they make; but we must take care that the education is of the right sort. Now, what will be the verdict of future generations on learning that the education which this great and powerful nation offers to the children of its artisans, to the class that will form the artisans of the next generation, was of a character purely literary, in no sense technical or even scientific? It is an education which, so far as it goes beyond the three elements of reading, writing, and arithmetic, is framed in all its essential features upon an exclusively collegiate type of studies; grammar, history, geography, foreign languages, and the like, being introduced, to the utter exclusion in all the most important of the successive "Standards" of any teaching of drawing, of mechanics, of the simplest facts of science or of natural history—of all, in fact, that most nearly concerns the workman throughout his entire career. In all the constructive trades the greater part of a workman's instructions are given to him in the form of working drawings. Yet we suffer the budding artisan to pass through the schools ignorant of the first rudiments of a science that is as essential to his work as are the four rules of arithmetic. And ought we, then, to be surprised if, in pursuance of the system we have deliberately marked out for the rising generation, we keep our future artisans, till they are fifteen or sixteen, employed in no other work than sitting at a desk to follow, pen in hand, the literary course of studies of our educational code, we discover that on arriving at that age they have lost the taste for manual work, and prefer to starve on a threadbare pittance as clerks or book-keepers rather than by the less exacting and more remunerative labor of their hands? At the present moment, this tendency to despise a life of honorable manual toil in straining after a supposed gentility would be truly pitiable, if the proportions it has attained did not awaken more serious apprehensions. It is an evil not confined to this country alone, but it is known, too, in the great cities of the States, of Germany, and of France. In a recent most able work upon primary education and apprenticeship in France, M. Salicis, a naval officer and cantonal delegate, speaks in forcible terms of the distaste for work of the children who leave the elementary schools of Paris: "These little bureaucrats, boys and girls,

outlaws from real labor by no fault of their own, come naturally to the end of their school course with one fear before them—that of being forced to become workmen and workwomen; but with one wish also, the boys to become clerks, the girls shopwomen. And hence this undefined, uncertain, overstocked class of book-keepers, cashiers, salesmen, clerks, agents with a thousand qualifications, scorning the cap and blouse for the sake of broadcloth and silk hat; and the corresponding class, still more to be pitied, of *young ladies*, of no shop, perhaps, and some with the coveted bonnet, but, alas! how procured?"

Obviously, with such facts as these staring us in the face, we must admit a flaw in the training given in our primary schools if its result is in so large a number of cases to destroy the natural capacity for manual labor. The fault is not so much in the amount of education as in the nature of the studies. For many trades the training of the hand to work may, and in some must, begin at an earlier age than that at which many children leave the elementary school. In some trades, indeed, the masters definitely refuse to take apprentices above a certain age; if they did take them the union would interfere. The taste for manual work is imbibed at a very early age, and there is not wanting evidence to prove most distinctly that even a very small amount of manual labor introduced into the elementary school serves to keep alive the capacity for active employment, and the manipulative skill of the fingers.

The first and most obvious step to be taken to bring about the urgently needed remedy is to render at least permissive, if not authoritative, a reform more or less sweeping in character in the instruction given in our elementary schools to boys and girls between the ages of ten and fourteen. For this class of children the provisions of our existing educational code could not possibly be more unsatisfactory than they are, when regarded from the point of view that these children will in a few months have to work for a part at least of their own living. The crumbling edifice of apprenticeship is made to repose upon a basis of literary studies which positively unfit the young apprentice to enjoy the few benefits which that obsolete institution can still offer.

The case is beset, then, with a double difficulty: that while the old system of apprenticeship is less and less able to afford a training worthy the name to the child of the artisan, the character of the education given him not only does not make up for that which apprenticeship can not now give him, but even predisposes him against the career of manual toil to which apprenticeship is the necessary and only adequate introduction. The reform needed, then, as a first step, is the substitution of certain technical and scientific studies for some of the literary studies at present prescribed. Not that these literary studies are not in themselves good—quite the reverse; only, they must be deferred till a little later in the educational course. Among the subjects

that will in lieu claim prominence are drawing * and the elements of the physical sciences so far as they can be illustrated by the common things of every-day life. That is the first and easiest step in reform, but it it does not probe to its depths the malady : at best it is little more than skin-deep. The distaste for work on the part of the artisan children on the one hand and the incapacity and ignorance which result from the chaotic state of apprenticeship on the other hand alike call for a more trenchant remedy. It is absolutely necessary, in the first place, that the children should enter earlier upon manual labor, that they may gain some skill with their fingers ere they pass the perilous point at which their taste or distaste for work may be acquired ; and, in the second, that their education, the training of their mental capacities, should continue till a later period, when their minds are more matured and their faculties sharpened by experience. The whole question of technical education lies in the simultaneous solution of these two problems.

THE GLACIAL MAN IN AMERICA.

By B. F. De COSTA.

IN that distant age when Nature was still toiling at the foundations of the Eastern Continent, portions of America had become dry land, and mountain-peaks in North Carolina were illuminated by rising and setting suns. It is, therefore, an anachronism to speak of America as the New World, especially when we remember the high antiquity of the fauna of North America. Still it is believed that the Eastern Continent was the original abode of man.

But when, or under what circumstances, did America receive her first human inhabitant? Heretofore those who have discussed the question have assigned the event to a comparatively modern period, and have considered the probability of immigrations from Asia by Behring Strait ; while others have suggested early transatlantic movements, or the peopling of America from a lost continent of the Pacific Ocean. The discovery of stone implements, however, in the glacial deposits of the Delaware Valley gives a fresh turn to the dis-

* I am not here advocating drawing as a fine art, much as we may hope the fine arts might do for the culture of the future generation, but *drawing as a science ;* by which I mean the representation of real objects to scale, as workmen have them represented in the drawings from which they work ; as, in the higher development, engineers and architects represent them. As is well known, this is frequently, though erroneously, described as "mechanical" drawing. Erroneously, for the sketches by which directions to workmen are conveyed may be of the roughest "free-hand" type provided only they are constructed upon the scientific methods in use in all the best workshops, and "figured"—that is to say, having the various dimensions accurately marked upon them.

cussion, and carries the question back to remote periods. It is true that the great antiquity of man on this continent had been maintained previously, but the evidence was quite unlike what is now offered. Yet, whatever may be concluded ultimately respecting the antiquity of the Delaware flints, it is quite apparent that the red-man found in America at the period of its rediscovery by Cabot, Vespucci, and Columbus, was not the descendant of any glacial man. No line of connection can be made out. This continent does not appear to have any Kent's Hole like that at Torbay, affording a continuous history, beginning with the cave-bear and ending with "W. Hodges, of Ireland, 1688." The race that rose to wealth and power in Central America did not succeed any rude spear-maker. More and more is it becoming evident that the people of Central America sprang from a superior race inhabiting the borders of the Mediterranean. This is indicated by a certain similarity in manners, customs, architecture, and religion. Investigations, now in progress, promise to yield the approximate date of the period when the first conquerors of Mexico and Yucatan crossed the sea. The Spaniards learned that the people whom they conquered had themselves figured in the *rôle* of invaders, entering from a country called Tulan or Tulapan, and overrunning the then dominant race. It may yet be demonstrated that this took place about the third year of the Christian era. But who were these earlier inhabitants? These we believe were not the descendants of an indigenous race, any more than were the later tribes. There is nothing to show that they were ever connected in America with any glacial or pliocene man. They might, however, be referred to still more remote migrations from Europe, which may have taken place in connection with events that gave rise to the story of the lost continent of Atlantis, as related by Plato. The so-called aboriginal red-man is comparatively a modern, although the author of "Leaves of Grass" asks concerning "the friendly and flowing savage," is he "waiting for civilization or past it and mastering it?" However this may be, he is wandering over the graves of peoples who left no record of their exploits, either in the continent where they sprung into life or where they died. It is, indeed, a significant fact that the East furnishes no very plain tradition of any exodus which peopled America. The prehistoric emigrant must have been possessed of the idiosyncrasies of those who

> ". . . . fold their tents like the Arabs
> And silently steal away."

The absence of such traditions is nevertheless not at all surprising, since the people of antiquity, and notably the Phœnicians, guarded their distant maritime discoveries with care. Indeed, we wholly misapprehend the spirit of that remote age, in supposing that the navigators would hasten to show the way to new-found lands, and proclaim their discoveries to all the world. This was not even the spirit of the

sixteenth century, for at that period, in the spirit of the Tyrian and Sidonian sailor, the Spaniards and the French had their plans for stopping the advance of other nations—the one by fortifying the straits of Magellan, and the other by holding the supposed route to the Indies by way of the St. Lawrence.

It is now gradually becoming apparent that the peopling of America was accomplished by more than one race of emigrants, and that at least two distinct expeditions went from Europe to Mexico and Yucatan before the Spaniards. This question, therefore, has its historic and archæological side, and consists of a number of very distinct lines, which are to be studied separately by specialists, in the conviction that no one theory or set of facts covers the whole ground. Several distinct contributions were made by the inhabitants of the Eastern Continent toward the peopling of America, and, by means of a careful division of labor, we may yet reach some satisfactory solution of a subject that has so long baffled inquiry. Such studies may be conducted on strictly scientific principles, as well as those prosecuted with relation to the story of life in general on this continent; for, if we may accept as historic the representation of Professor Marsh, who pictures the American primates making their way over the miocene bridge at Behring Strait to Europe, and failing, later, when differentiated, to return, because the bridge had broken down, man alone returning to the country of his "earlier ancestry," it is certainly reasonable to hope that the origin of those races not connected with the in-comer by Behring Strait may be satisfactorily explained.

At what period the Atlantic was first crossed by man it is impossible now to conjecture. It was nevertheless navigated in very early times, and was a sea of light, though at the dawn of history it appears as the "Sea of Darkness," inspiring no little apprehension and dread; while Albinovinus sends out Germanicus upon the sea with a *ruit ipsa dies.* Under the circumstances, therefore, the old discussions will be continued, though the subject of the glacial man in America may be pursued as something wholly independent.

But was there any glacial man in America? To this question the answer is distinct, though given with the reserve which the subject justifies. For the best that is known, we are chiefly indebted to Dr. C. C. Abbott, who was the first to call attention to the stone implements found in the glacial deposits of the Delaware Valley. These implements are chiefly of argellite, though examples of flint occur at higher levels. They have been found at the bluffs near Trenton, both in position where deposited and among the *débris* at the base. Dr. Abbott says, "Perhaps it is a wise caution that is exercised in but provisionally admitting the great antiquity of American man, but, were these rude implements not attributed to an inter-glacial people, their coequal age with the containing beds would never have been questioned." On this point the Curator of the Peabody Museum at

Cambridge observes, in the tenth annual report: "Dr. Abbott has probably obtained data which show that man existed on our Atlantic coast during the time of, if not prior to, the formation of the great gravel deposit which extends toward the coast from the Delaware River, near Trenton, and believed to have been formed by glacial action. From a visit to the locality with Dr. Abbott, I see no reason to doubt the general conclusion he has reached in regard to the existence of man in glacial times on the Atlantic coast of North America."

The support given to Dr. Abbott's conclusions by investigators stamps them as of high interest, while his own arguments are entitled to the same respectful consideration. Several of his observations are not easily set aside. For instance, he says, "if the same age is ascribed to these paleolithic implements and the ordinary Indian relics," then, as already asked, "how could the one series become imbedded, often to great depths, and not representatives of any class of weapons, domestic utensils and ornaments?" It would, indeed, be a singular operation of Nature, that selected one class of relics only for preservation. The conclusion is, "that in the essentially unmodified *débris* of the terminal moraine in central New Jersey, and in others upon the surface (which, however, are in part only of more recent origin), it is shown that the occupancy of this portion of our continent by man extends back into the history of our globe, in all probability to even an earlier date than the great ice age; and that the maximum severity of the climate did not destroy him; and that subsequently he tenanted our seacoast and river-valleys, until a stronger and more warlike race drove him from our shores."

It is not the purpose of the writer, however, to attempt to add anything to the argument, especially as he is assured that the question now seems to concern the probability of man having existed in America *prior* to the glacial period. We, therefore, take the evidence as it stands, leaving its strengthening or overturning, as the event may prove, to the future, aiming in this article to give a fuller illustration than has heretofore been attempted of the agreement of the theory with accepted history; for, possibly, it may eventually appear that the glacial man is more closely connected with historic man than could have been expected.

Professor Marsh observes, that "the evidence, as it stands to-day, although not conclusive, seems to place the first appearance of man in this country in the Pliocene," adding that "the best proofs of this are found upon the Pacific coast." The proofs, however, are a little shadowy, consisting of a stray bone or two, instead of stone axes and arrow-heads; though it is clearer that some of the first inhabitants, whenever they came, entered from Asia by Behring Strait, the destruction of the miocene bridge, which once existed there, not impeding their advance. It is unnecessary, however, to suppose that the glacial man was unable to find his way westward from Central Europe.

The notion that man in that remote age could not navigate great seas is simply a notion, and likewise it is a notion that more than anything else prevents the advance of scientific inquiry respecting the early colonization of America. Two men in a skiff to-day navigate the entire breadth of the Atlantic, but such a feat forms no new thing under the sun. In the glacial age communication between Europe and America may have been more easy than is now suspected, while a large portion of the journey may have been made over fields of ice. The passage of the glacial man from Europe possibly presented no greater difficulties than the migration of the Esquimaux from Labrador to Greenland. But, however man may have reached America, the theory that the Indian peoples sprang from any glacial stock seems untenable. This, then, necessitates the inquiry respecting the subsequent history of the primitive inhabitant; otherwise, what became of him?

That a people corresponding in the main to the supposed glacial man once dwelt as far south as New Jersey has been agreed by various writers, without any reference to the contents of the glacial deposits, of whose existence they did not dream. When, for instance, we turn to the Icelandic Sagas relating to America, it becomes apparent that the Esquimaux once flourished low down upon the Atlantic coast.

At the present time historians agree, with great unanimity, that the continent of America was visited during the tenth and eleventh centuries by Icelanders resident in Greenland. That country was colonized by the Icelanders in the year 985, and when Eric the Red entered Greenland he found no inhabitants. The third Greenland "Narrative," however, says: "They found there, both east and west, ruins of houses and pieces of boats and stone-work begun. From which it is to be seen what kind of people lived in Vinland, and which the Greenlanders call Skrællings, and who have been there." * Thus at that early period the remains in Greenland were identified as works peculiar to the people of Vinland, a region, according to the Sagas, lying southward toward the forty-first parallel.

The account of what the Icelanders saw in Vinland is found in the narratives of Leif and others. In 986 one Biarne, when sailing for Greenland, was blown upon the American coast, and upon his return carried the report of the country to Greenland. In the year 1000, Leif Erickson resolved to visit the region seen by Biarne, and, sailing southward from Greenland, reached the place. The narrative says: "The country appeared to them of so good a kind that it would not be necessary for them to gather fodder for the cattle in winter. There was no frost in winter, and the grass was not much withered." The observation that there was no frost was simply an exaggeration natural to an Icelander coming into a country with a climate so unlike that to which he had been accustomed. Morton wrote home to Eng-

* "Pre-Columbian Discovery of America by the Northmen," p. 20.

land that coughs and colds were *unknown* in New England. Leif's narrative says nothing about any inhabitants; but, in 1002, Thorvald, his brother, sailed to Vinland and found some people at a place a little to the northward of Leif's resort. The Saga says that one day, when opposite a cape, they "saw three specks upon the sand," and that, upon examination, they found that these were "three skin-boats with three men under each boat." Cruelly attacking them for the plunder, the Icelanders killed eight, while one man escaped with his boat. They also saw "several eminences which they took to be habitations." Afterward, they rested and fell asleep on board their vessels, only to be awakened by the natives, who had been notified by the man that escaped, and who had now come to avenge the death of their comrades. When the alarm was sounded, "an innumerable multitude, from the interior of the bay, came in skin-boats and laid themselves alongside." The Northmen at once put up their "war-screens" on the gunwales, and, the Saga says, "the Skrællings shot at them for a while, and then fled away as fast as they could." They did not retreat, however, before dealing Thorvald, the leader of the expedition, his death-wound, it being given by an arrow which struck under his arm. Thorvald was buried on the shore, supposed to be the coast of Massachusetts Bay.* This is the first recorded collision between Europeans and those whom we propose to call the descendants of the glacial man. It shows them as strong and not wanting in the courage that would fit men for the struggle with nature during the great ice period that prevailed in America.

In 1006 Thorfinn Karlsefne sailed to Vinland with an expedition, and reached the place formerly visited by Leif and Thorvald, where they wintered in a very mild climate. But one spring morning, while on an exploring expedition, apparently near Long Island Sound, when "they looked around, they saw a great many skin-boats and poles swung upon them, and it sounded like reeds shaken by the wind, and they pointed toward the sun. Then said Karlsefne, 'What may this mean?' Snorre Thorbrandson replied, 'It may be that this is a sign of peace, so let us take a white shield and hold it toward them.' They did so. Thereupon they rowed toward them and came to land. These people were swarthy and fierce, and had bushy hair on their heads; they had very large eyes and broad cheeks." The Northmen, however, were not attacked, and remained there until spring, the statement being that "there was no snow, and all their cattle fed themselves on the grass." But in the opening of 1009 the Skrællings returned, offering "skins and real furs" for red cloth, the Northmen refusing to sell them swords and spears. Finally, a bull which belonged to the Icelanders began to bellow, when the Skrællings became frightened, and ran to their boats, rowing away south. At the end of three weeks, nevertheless, "a great number of Skrælling boats were seen coming from

* "Pre-Columbian Discovery of America by the Northmen," p. 41.

the south like a rushing torrent, all the poles turned from the sun, and they all yelled very loud." Karlsefne saluted them with his red shield, the sign of war, "and after this they went against each other and fought. There was a hot shower of missiles, because the Skrællings had slings." At the outset, Karlsefne was forced to retreat, but a rally was made, and the Skrællings retreated. It is also said that "two men fell on Karlsefne's side, but a number of Skrællings." The Saga states that Karlsefne was overmatched, so many natives appearing that it was difficult to believe that they were real men, but rather optical illusions. In connection with the fight an incident occurred which seems to show that the Skrællings belonged to a people of the stone age; for one of them found an axe and cut a piece of wood with it, and thought it was a "fine thing." But when he tried to cut a stone it broke. Then "they thought it was of no use, because it would not cut stone, and they threw it away." It would appear from this that stone was their standard.

Afterward, during a short expedition northward, the Northmen found "five Skrællings clad in skins, asleep near the shore. They had with them vessels containing animal marrow mixed with blood." These were killed. Soon after they fancied that they saw men with one leg called "Unipeds," and for this piece of imagination the narrative has been objected to as unreal, the objector forgetting that the Uniped is a very ancient institution frequently mentioned by sailors. Charlevoix reports a St. Malo captain, who, when in America, saw men with "one leg and thigh." A young Labrador girl captured in 1717 told of those her countrymen who had only one leg.

Finally, Karlsefne decided not to expose his little colony, and prepared to sail for Greenland. On the voyage home they landed in Markland, supposed to be Nova Scotia, and "found there five Skrællings, and one was bearded, two were females and two boys; they took the boys, but the others escaped, and the Skrællings sank down into the ground"; that is, disappeared among the hillocks or slipped into their subterranean dens. The Saga says that the boys were taught Icelandic and were baptized. They called their mother Vathelldi, and their father Uvæge. They also said that two kings ruled over the Skrællings, one being named Avalldania and the other Valldida. These boys also reported that they had no houses in Markland, but that the people lived in "caves or holes."

The second narrative of Karlsefne treats the subject of the Skrællings in the same way, except that these people were of "small stature." The third narrative states that, when the bull (one of the small Icelandic species) began to bellow, the Skrællings "made off with their bundles, and these were of furs, and sables, and all sorts of skins; and they turned and wanted to go into the houses, but Karlsefne defended the doors." Also, before the fight commenced there was more trading, and the women brought out "milk and dairy products," which pleased

the Skrællings so much, that, as the Saga says, "they carried away their winnings in their bellies." Such is the account that we have of the Skrællings in the Sagas relating to America. These people do not appear to be referred to again in connection with the voyages, though a geographical fragment mentions "Helluland," which is called "Skrællings Land," not far from Vinland the Good.*

The delineation of the people found by the Icelanders in the mild regions of the Atlantic coast is brief, but it is sufficient to fix their character. Rafn, when editing the original Icelandic records, pointed out the fact that these people agree with the Esquimau and Greenlander of to-day. The critic who supposed that the Saga writer should have described a people with the characteristics of the red-man fancied that he found an error indicating their unhistorical character. The Indian, however, was a late comer upon the extreme eastern border of North America. Indeed, the oldest distribution of the American races does not antedate the tenth century, and therefore the appearance of the Skrælling in the Sagas, instead of the Indian, is precisely what the truth required.

It is hardly necessary to restate the points in the description; for, instead of the tall red-man found by later voyagers on the coast, so gentle, kindly disposed, generous, and hospitable—traits wellnigh obliterated by subsequent contact with the whites—we have men of short stature, bushy hair, rude, fierce, and devoid of every grace. Also, here in a country covered with fine forest-trees, the principal article of value to the Icelander, the people made their boats of skin like the Greenland *kyjack*, instead of the bark or the trunks of trees, as often practiced by the Indians, and described by Champlain.† The men described in the Saga evidently did not know the use of metals, and they despised the axe when it was found that it would not cut stone. In the fight with Karlsefne's men they slew Thorbrand with a flat stone (*hellusteinn*), perhaps a celt, which they "drove into his head," thus illustrating, possibly, the rude warfare of the glacial man. Nor should it be forgotten that, while even in the dead of winter the New England Indians wore almost no clothing, these men, encountered by the Icelanders were clad in furs after the spring had set in.

Another resemblance is found in the fact that both the Skrællings and the Greenlanders used slings, the latter being mentioned by Davis, the first European who visited Greenland in modern times. But a still more valuable fact is mentioned by this writer in connection with the voyage of 1585. It has already been stated that, when in Vinland, Karlsefne found that the Skrællings used to indicate peaceful intentions by pointing certain implements toward the sun, while, when turned from the sun, they indicated war. Thus in Greenland the natives, to indicate peaceful intentions, pointed to the sun with their

* "Pre-Columbian Discovery," etc., p. 49.

† "Œuvres," tome iii, pp. 59, 60.

hands, after striking their breasts, refusing to trust themselves with the English until the latter had done the same, through one of their number appointed for the purpose, "who strooke his breast and poynted to the sunne after their order." Davis thus appears as dealing with descendants of the glacial man.

If we are correct in supposing that there was a glacial man, and that the Skrællings were descendants of such a glacial man, it follows that we have in the Sagas four of his words, which may be the oldest known words of human speech: "Vathelldi," "Uvæge," "Avalldania," and "Valldida," the names of the parents of the Skrælling boys and of the two kings. At least, in a recent note addressed to the writer, Professor Max Müller says that there is nothing in the language of the Esquimaux to prevent us from assigning it to an antiquity as high as that of the supposed glacial man.

During the eleventh century the red-man lived upon the North American Continent, while the eastern border of his territory could not have been situated far away from the Atlantic coast. In New England he must have succeeded the people known as Skrællings. Prior to that time, his hunting-grounds lay toward the interior of the continent. In course of time, however, he came into collision with the ruder people on the Atlantic coast, the descendants of an almost amphibious glacial man. Then the coast-dweller, unable to maintain his position, retreated toward the far north. The northward movement, however, may have been voluntary in part. During long ages passed in the companionship of the glacier, the race must have acquired that taste and fitness for boreal life which clings to the native of the north to-day, and which makes the Greenlander feel that his country is the most beautiful in the world.

The advance guard of the Skrællings had reached Greenland before Eric the Red arrived in 985. He found there, as we have seen, both houses and boats, but no inhabitants. It was inferred, at the time the Saga was committed to writing, that the remains belonged to a people of the same race as those seen in Vinland at the south. These early Skrælling visitors had either perished or retired from Greenland. The Icelanders do not appear to have met any Skrællings in Greenland until a late period—at least none are mentioned. But in the twelfth and thirteenth centuries the Skrællings crowded into Labrador and the regions bordering Baffin's Bay, preparatory to the movement across to Greenland, though many of them may have crossed to North Devon and entered at the northwest. It is probable that extreme necessity was all the while urging them on, the red-man crowding upon their rear with great energy. This is evident from the fact that, when the French entered Canada, the region north of the St. Lawrence was occupied by the Indians. The struggle between the Indians and the Skrællings was long continued, and one evidence of the contact may be found in the common use of a certain engine of

war, which the Saga says was employed by the Skrællings in their fight with Karlsefne.

It is said, "Karlsefne's men saw that they raised up on a pole a very large ball, something like a sheep's paunch, and of a blue color; this they swung from the pole over Karlsefne's men upon the ground, and it made a great noise as it fell down. This caused great fear with Karlsefne and his men." The statement at first appears curious and almost childish; yet in Schoolcraft's work on the Indians (vol. i, p. 83) may be found a description of a similar engine employed in the ancient times, when the red-man used to sew up a round bowlder in the skin of an animal, and hang it upon a pole borne by several warriors, which, being swung against a group of men, did great execution. The Skrællings may, therefore, have acquired the idea in their fights with the more skillful red-man then pushing his way into their territory. Pursued by a superior force, we may conclude that the Skrællings retreated into the north. Dr. Abbott himself is of this opinion, saying, "When, also, we consider that the several conditions of glacial times were largely those of Greenland and Arctic America, and that there is unbroken land communication between the desolate regions of the latter and our own more favored land, and, more important than all, that there now dwells in this ice-clad country a race which, not only in the distant past, but until recently if they do not now, used stone implements of the rudest pattern—it is natural to infer that the traces of a people found here, under circumstances that demonstrate a like condition of the country during their occupancy, are really traces of the same people."

That the country as far south as New Jersey was formerly adapted to boreal tribes is evident from the fact that the walrus has been found at Long Branch, while the great auk formerly flourished around the borders of Mount Desert in Maine. Dr. Henry Rink, who for so many years superintended the Danish interests in Greenland, and who studied the question without any reference to the glacial man, reached the conclusion that the "Esquimaux appear to have been the last wave of an aboriginal American race, which has spread over the continent from more genial regions, following principally the rivers and watercourses, and continually yielding to the tribes behind them, until they have at last peopled the seacoast." Originally their distribution was very wide, and their language prevails to-day from Greenland to Labrador and the northeastern corner of Siberia. Professor Dawkins holds that the paleolithic cave-dwellers of Europe were of the same race as the Esquimaux or Innuit, though no such connection can be shown between them as exists between the ancient Skrællings and the Esquimaux.

The Icelandic records prove that the conflicts begun with the Skrællings in the eleventh century in New England were renewed in the fourteenth in Greenland. Possibly it is to the Skrællings that

the final extinction of the Icelandic colony in Greenland may in part be attributed. Nevertheless, from the year 985 down to the vicinity of 1335, the Skrællings, so far as the records go, do not appear to have given any trouble. But about that period they suddenly appeared in force. At that time the western coast of Greenland was divided into two districts, called the East and West Bygds, there never having been any Europeans permanently inhabiting the eastern coast, though the Saga of "Thorgill's Nursling" shows that a family or two of Skrællings may have dwelt there.

That the Skrællings appeared in considerable force is indicated by the fact that an expedition was organized to meet them. The "Chronicle" of Ivar Bardsen * shows that Bardsen himself was selected by the colonists as their commander. This "Chronicle" was composed during the second half of the fourteenth century, but it is impossible to say in what year. It is certain, however, that upon the 6th of August, 1340, Haquin, Bishop of Bergen, in Norway, commissioned Bardsen to act in Greenland, as the latter was born in that country, and was perfectly acquainted with all its affairs. His commission is still preserved at Copenhagen, and a copy may be seen in Rafn's "Amerikas Arctiske landes gamle Geographie," p. 47. Whether the Greenland colonists appointed him their leader before or after 1340, it is impossible now to say. Crantz, in his work on Greenland, intimates that the killing of some eighteen persons by the Skrællings led to the appointment of Bardsen. The natives gave Crantz a tradition respecting a fight between their Skrælling ancestors and the colonists, whom they called "Kablunæts." A quarrel sprang up about shooting arrows, and blood was shed, the natives declaring that the Kablunæts were exterminated. This may possibly explain what became of the remnant of Europeans left in Greenland in the fifteenth century, but it can not refer to the fourteenth, as the communication was kept up with Greenland during that period. It was in the year 1379 that the eighteen colonists were slain. "Islenzkir Annalar," page 331, says, under that year, that hostile Skrællings invaded Greenland, killing eighteen men, and carrying away two boys captive. It is probable that from this time the Skrællings proved formidable, though, when Bardsen went into the western district to meet them, they were nowhere to be found, having either hid themselves or fled into the inaccessible fastnesses of the north. He nevertheless secured some of the cattle belonging to the colonists, and returned southward to what was called the East Bygd. In Bardsen's time the West Bygd was evidently abandoned, owing to the weakness of the colonists; and he says, in his "Chronicle," that "now the Skrællings inhabit all the west land and Dorps." It must have been from the deserted West Bygd that they came to attack the colonists in 1379. The Icelandic annals of the fourteenth century mention no more fighting in

* Published by Munsell, Albany, as "Sailing Directions of Henry Hudson."

Greenland, and in the fifteenth century Greenland is not mentioned. In this manner Old Greenland passed from sight, and it was not until the seventeenth century that the country was reoccupied by Europeans. Some have supposed that the ancient colony was cut off by the plague, but the little remnant may have been exterminated by the Skrællings, as the modern natives averred.

The foregoing brief statement of historical facts puts the modern Esquimaux, or Innuit, in connection with a people who dwelt along the temperate regions of the Atlantic coast in the eleventh century. It also indicates that these rude people were driven by a superior race into the far north, where they succeeded the Europeans. These people were also of very great antiquity. What, then, was their origin? Who else could they have been than the descendants of a glacial man?

It is true that none of the bones exhumed on the Atlantic coast have been identified as those of the Esquimaux, though if they existed as late as the eleventh century such remains should be found. Hitherto, however, they have not been looked for, nearly everything exhumed being attributed to the red-man as a matter of course. Nevertheless, there have been those who have not felt satisfied with such a disposition of the whole subject. In many localities of Maine, for instance, the opinion has prevailed of late that many of the shell-heaps were not of Indian origin, and that they should be referred to a more ancient people. Certain indications attracted the attention of the writer long before any glacial man was spoken of. On this point Dr. Abbott makes a suggestion, and argues that the stone implements found indicate two races, one much more advanced than the other. He writes: "When we come to examine a full series of ordinary surface-found arrow-points, as we gather them by the score from our fields, and occasionally find associated with them a rude implement of the type of those found in the gravel-beds, we are naturally led to draw some comparisons between the two widely different forms. The arrow-heads and others, which from their size may be considered as spear- or lance-heads, are of two quite different types, being those made of jasper, chert, quartz, and rarely of argillite, of a dozen different patterns, and those of argillite of a nearly uniform pattern, and of larger sizes as a rule; all greatly weather-worn, and varying notably from the arrow-points of other minerals in being of much coarser workmanship, and in this respect seeming to be a natural outgrowth of the skill once exercised only in producing the primitive forms of the glacial drift."

But what have the modern Greenlanders to say respecting their origin? They told Crantz that all the people of the earth originated from one man, who came from the earth, his wife springing from his thumb. This may be their version of what their ancestors learned from the Icelandic colonists who were Christians. Such stories throw no light upon their history, though the Esquimaux gave their family

genealogies for ten generations. There is nevertheless something in other accounts related by them which may possibly suggest traditions relating to changes that had taken place upon the globe in the past, and traditions that might have come down from the glacial period, when Nature conducted her operations upon such a stupendous scale. It would appear as though their rude intelligence had argued what would take place in the future from what had transpired in the past. For instance, it was their belief at the time the missionary came among them, that all of the present race would become extinct, and the earth be broken up by some widely operating force, and then purified by a vast flood of water, after which the dust of the earth would be blown together and become more beautiful than before, as the rocks would disappear, being covered with verdure. Now, in this was their fancy stimulated by traditions that had come down to them from glacial ancestors, concerning what we call geological epochs, or was this also taught them by the Northmen? It is, perhaps, to be regretted that we have so few of these relations by the early Greenlander, as they might have proved useful in connection with the attempt to solve the question of his origin. Nevertheless, the case is by no means hopeless, and testimony may yet be discovered that will connect him beyond question with the glacial man.

A FLOCK OF MYTHOLOGICAL CROWS.

By W. H. GARDNER, M. D.

PERHAPS there are but few persons who have read Poe's "Raven," or Dickens's "Barnaby Rudge," who have not felt some curiosity to learn why ravens and crows, more than any other birds, should be invested with characters so ominous and demoniacal. And not only do these birds bear this ominous reputation in poetry and fiction, and in the legends and folk-lore of many of the nations of the earth, but by the unlearned they are still looked upon as too weird and uncanny for ordinary birds; and many a person can be found even in this age of positivism who would consider a crow lighting upon his house-top as certain a harbinger of evil as Hesiod did, seven hundred and fifty years before Christ, when he said to his brother Perses, "Nor when building a house, leave it not unfinished, lest, mark you, perching upon it, the cawing crow should croak." *

In this age, our plane of thought is so far above that of our rude and ignorant ancestors that their superstitions and myths seem too puerile to merit notice; but when we study them attentively, with

* Hesiod, "Works and Days."

the light which comparative mythology is able to throw upon them, we find that what at first seemed only childish fables are really degraded fragments of the religion of our forefathers, and as such they are surely worthy of the attention of their descendants.

In the infancy of mankind almost every system of mythology included the worship or veneration of animals. In one land the deity was a bull, in another it was a serpent, in yet another it was a bird; and in lands like India and Egypt almost every known animal was either an incarnated deity or demon. The same reasons that caused the animal to be deified and worshiped would, in a short time, surround its worship with numberless myths and legends, that would be remembered long after the occasion that called them into existence had been forgotten. As an instance of this, we need only cite the return of the Israelites in the desert of Sinai to the worship of the golden calf—the image of the Apis god of the Egyptians—they probably being no more aware that under this *eidolon* was represented the sun-god in the zodiacal sign Taurus than were the mass of the Egyptians themselves. Still another reason why these myths and legends would remain long after their real meaning had been forgotten, is due to the metaphoric nature of all early languages; and this cause would act still more strongly if the various shades of meaning of each metaphorical term were not limited by accurate writing. Brinton says the Algonquins, who translated "Michabo" into "The Great Hare," lost by a false etymology a great part of their religion, the true meaning of the term undoubtedly being, "The Spirit of the Light" or "The Dawn."*

The great storehouse of myth and fable for all the Indo-European nations is the sacred books of the Hindoos; and it is here, among the religious beliefs of these old Nature-worshipers recorded away back in the morning of time, that we should first look for myths concerning the crow. In this curious pantheism all nature was divided into two opposing principles: the one containing all that was bright and life-giving and beneficent for mankind—devas; the other including all that was dark and malignant and destructive—demons. Among these malignant powers of nature, we find frequent mention made of the crow, and usually associated with such ill-omened animals as the wolf and the owl. De Gubernatis says that in the Vedic hymns the term "vrikas" may mean both wolf and crow;† but we find that, though the wolf and the crow were equivalent in many respects, and were both enemies to the devas or bright gods, yet the wolf was *always* demoniacal, while the crow in some of its aspects was benignant; and when the sun-god had finished his daily battle with dragons and monsters, and had sunk into the sleep of death, the crow bore him on his pinions down into the dismal land of darkness and the

* Brinton, "Myths of the New World," pp. 178, 179.

† Angelo de Gubernatis, "Zoölogical Mythology," vol. ii, p. 250.

dead. In the last book of the "Râmâyana," we also find that, when the gods were fleeing before the demons, Yama, the god of the dead, borrowed the plumage of the crow in order to escape, in payment for which service he gave the crow the privilege of eating the funereal food.

In the Grecian mythology, at least as early as the days of Hesiod, the character of the crow or raven (κοραξ), as a prophet of evil, had already been established (see *ante*, page 43) ; yet we find it here also sacred to the sun-god and usually associated with the same malignant animals as in the Hindoo mythology.

Our Hellenic myths say that, "once upon a time, Apollo sent his feathered attendant, the raven, who was then pure white, to bring water for sacrifice, but the raven, finding a fig-tree with fruit nearly ripe, waited until it should mature and he could appease his hunger ; then, having to account for his delay, he took a water-snake out of the fountain, placed it in the pitcher, and brought it to the god, and told him that the snake had daily drunk the fountain dry. But Apollo was not to be deceived by any such story, and, as a punishment for his crime, he turned the raven black, and condemned him to be tormented with thirst during the season that figs are ripening." *

Another says that "Apollo was in love with a beautiful nymph of Thessaly named Koronis, but she was false to the god, and was surprised with another lover by the raven, who flew off without heeding her entreaties and told his master ; the god in a transport of jealousy slew the faithless damsel, and then, angry at the tattling raven for bringing him the unwelcome tidings, he turned his plumage black." †

In the Grecian myth of the battle between the gods and the giants, Apollo is said to have disguised himself in the plumage of the crow, as we have before seen was done by Yama, in the Hindoo version of the story.

In the Roman mythology there were wanting many of the idealistic conceptions of the Greek mind, and even the glorious Apollo was not given a place in the Roman pantheon until a late day. Cicero says, "The whole religion of the Romans at first consisted of sacrifices and divination by birds." ‡

Besides the sacred geese and chickens which were always on hand and kept in proper condition to consummate the "*tripudium solistimum*," whenever the good of the state required it, the Roman college of augurs divided all other birds, for the purposes of divination, into two general classes—*Alites*, those from which the augury was taken by observing their direction and manner of flight ; and *Oscineo*, those in which the augury was taken from the voice or cry. Of the latter class none were considered more sacred or more certainly ominous than the crow and raven, though Cicero says, "The croak of a

* Eratosthenes. † Ovid. ‡ Cicero, "De Nat. Deorum."

raven on the *right* hand or a crow on the *left* was reckoned a good omen." *

Early Roman history records more than one instance when the hoarse croak of the raven and warning voice of the crow have been heard and heeded in the councils of the nation, and sometimes even turned the doubtful issues of a battle. In the war with the Gauls which occurred in the consulship of Camillus, Livy tells us that "when the opposing armies were drawn up ready to join in battle, a Gaul of gigantic size stepped to the front and defied any one of the Romans to meet him in single combat. His challenge was accepted by Marcus Valerius, who was assisted in the fight by a crow, that, suddenly appearing, lit on the helmet of the Gaul and attacked him with beak and talons until Valerius slew him, when the crow flew away to the east. The death of the Gallic champion brought on a general battle, in which the Gauls were beaten and forced to retreat. After this remarkable event, Marcus Valerius was surnamed Corvus." †

Pliny tells of a sedition that occurred in Rome in consequence of the killing of a raven, and, though we can hardly relegate this probably historic incident to the domain of mythology, yet it will serve to show the peculiar veneration in which these birds were held by the ancient Romans. He says:

"A raven, that had been bred upon the top of the temple of Castor, flew down into the shop of a shoemaker which stood opposite; the shoemaker took much delight in its visits, and taught it to speak, after which it would fly every morning to the rostra overlooking the forum, whence, addressing each by name, it would salute Tiberius, then the Cæsars, Germanicus and Drusus, after which it would greet the Roman people as they passed, and then return to the shop. For many years it was constant in its attendance; but at length another shoemaker, envious of the popularity of his fellow craftsman, killed it; upon which the people became so enraged at the cruel and irreligious wretch that they drove him from the city and eventually put him to death. The funeral of the bird was celebrated with almost endless obsequies; the body was placed upon a litter carried by Ethiopians, preceded by a piper, and was borne to the pile with garlands of every size and description." ‡

Among the Scandinavian gods, the highest throne was assigned to Odin—the *Alfader*. And, though there was but little in his cruel and relentless character to remind us of the bright and life-giving Vishnu, or the glorious and benignant Apollo, yet there is no doubt but what he was another apotheosis of the sun, only with attributes so changed as to suit the ideal of a stern and warlike race, who had not only brute and human foes to contend against, but even to wage continual war against Nature herself. In the Norse mythology, both

* Cicero, "De Divinatione."

† Livy, lib. vii, chap. xxvi.

‡ Pliny, "Hist. Nat.," lib. x, chap. lx.

wolves and ravens were sacred to Odin. In the prose or elder Edda, which was the sacred book of the Odinic mythology, it is said, "Odin gives the meat that is set before him to two wolves, called Geri and Foeki, for he himself stands in no need of food." * And, again: "Two ravens sit on Odin's shoulders, and whisper in his ear the tidings and events they have heard and witnessed. They are called Hugin and Munin (mind and memory). He sends them out at dawn of day to fly over the whole world, and they return at eve toward meal-time. Hence it is that Odin knows so many things, and is called the ravens' god." †

Turning now to the Semitic tribes, we will find that among them, also, ravens were held in greater veneration than any of their feathered congeners; and more than one mention of them is made in the sacred chronicle as especial messengers of the prophets. In the Biblical narration of the deluge, we read: "And it came to pass at the end of forty days, that Noah opened the window of the ark which he had made; and he sent forth a raven, which went to and fro, until the waters were dried up from off the earth." ‡ And, again, after the prophet Elijah had foretold to the wicked King Ahab how the land would be cursed with drought, the word of the Lord came to him, saying: "Get thee hence and turn thee eastward, and hide thyself by the brook Cherith that is before Jordan. And it shall be that thou shalt drink of the brook; and I have commanded the ravens to feed thee there. So he went and did according to the word of the Lord; for he went and dwelt by the brook Cherith that is before Jordan. And the ravens brought him bread and flesh in the morning and bread and flesh in the evening, and he drank of the brook." §

In the Babylonian legend of the deluge, as given in the fragments of Berosus, we have also the episode of the birds being sent out to see if the waters had subsided, but neither the raven nor the dove is especially mentioned by name; ‖ while in the legend as given by the old Arabian chronicler, Abou-djafar Mohammed Tabiri, he not only mentions the raven especially being sent forth first, but also gives the reason of his not coming back: "Noah said to the raven, 'Go, and place your foot on the earth and see what is the depth of the water.' The raven departed; but, having found a carcass, it remained to devour it, and did not return. Noah was provoked, and he cursed the raven, saying, 'May God make thee contemptible among men, and let carrion be thy food!'" ¶

We have another legend—of the raven as a grave-digger—which is given in Baring-Gould's "Legends of Old Testament Characters" as follows: "After Abel was slain, Adam and Eve sat beside the body and wept, and knew not what to do. Then said a raven whose friend was dead, 'I will teach Adam a lesson.' And he dug a hole in the soil,

* Mallet's "Northern Antiquities," p. 430. † Mallet, *loc. cit.* ‡ Genesis, viii, 6, 7.
§ 1 Kings, xvii, 3–6. ‖ Berosus in Cory's "Ancient Fragments." ¶ Tabiri, c. 12.

and laid his friend there and covered him up. And when Adam saw this he said to Eve, 'We will do the same with Abel.' God rewarded the raven for this by promising that none should ever injure his young; that he should always have meat in abundance, and that his prayer for rain should be immediately answered."

From the same source we select one more legend, in which the raven appears as the possessor of a valuable secret, which, upon compulsion, it teaches the great king: "While Solomon was building the temple, he captured Iachr, one of the most powerful of all the jinns; and, having the demon bound and completely in his control, he promised him his liberty if he would tell him how the hardest metals could be cut and shaped without noise. 'I myself know of no means,' answered the demon, 'but the raven can tell thee how to do this. Take the eggs out of the raven's nest and place a crystal cover upon them, and thou shalt see how the raven will break it.' Solomon followed the advice of Iachr. A raven came and fluttered some time around the cover, and, seeing that she could not reach her eggs, she vanished, and returned shortly with a stone in her beak, named *iamur* or *ichamir*, and no sooner had she touched the crystal therewith, than it clave asunder. 'Whence hast thou this stone?' asked Solomon of the raven. 'It comes from a mountain in the far west,' replied the bird. Solomon commanded a jinn to follow the raven to the mountain and bring him more of those stones. Then he released Iachr as he had promised. When the jinn returned with the stone ichamir, Solomon went back to Jerusalem, and distributed the stones among the jinns whom he had employed in building the temple."

In the Egyptian mythology we have no single equivalent of the glorious sun-god of the Greeks; and, though the Rosetta-stone has explained to us the mystery of the hieroglyphs, and revealed the long-hidden meaning of many of the sculptured monuments and half-effaced papyri of the land of the Pharaohs, yet much of her curious mythology is a sealed book, and the attributes of some of her unique gods are still enigmas even to the most learned Egyptologists. Osiris, Aroueris, (the elder Horus), Harpocrates (the younger Horus), Chnum, Ra, Tum, and Mentu were all deifications of the sun during some part of the day or year; but it is no easy matter to limit the peculiar province of each god, or give his exact equivalent in Greek thought; and though Herodotus and other Greek writers assert that Horus was the same as the Greek Apollo, even this throws but little light upon the subject, since there were *two* Egyptian gods bearing this name, and several (probably deified) kings, one of whom restored the worship of the sun, after it had been forbidden by Amenophis IV, and had been neglected for nearly one hundred years. However, it is at least certain that Horus was worshiped by the Egyptians as the embodiment of the sun in a part of his course, and to him were sacred the hawk, the wolf, and the crow. Pritchard, quoting from Æolian's "History of Animals," says,

"The Egyptians reverence the hawk as sacred to Apollo, whom they name, in their language, Horus." *

And again, quoting from the same authority: "The crow also was sacred to Apollo, or Horus. In the neighborhood of Coptos only two individual birds of this species were to be seen, which belonged to the temple of Apollo." †

Coming now to the rude and primitive mythology of the red race of America, we find here also several tribes by which these birds were held sacred. And curiously enough, in the Algonquin myth of the deluge, we find both the raven and the wolf as attendants on Messon, the Great Spirit. Brinton quotes it from Father Le June as follows: "One day as Messon was hunting, the wolves which he used as dogs entered a great lake and were detained there. Messon, looking for them everywhere, a bird said to him, 'I see them in the middle of this lake.' He entered the lake to rescue them, but the lake overflowing its banks, covered the land and destroyed the world. Messon, very much astonished at this, sent out the raven to find a piece of earth wherewith to rebuild the land, but the bird could find none; then he ordered the otter to dive for some, but the animal returned empty; at last he sent down the muskrat, who came back with ever so small a piece, which, however, was enough for Messon to form the land on which we are. The trees having lost their branches, he shot arrows at their naked trunks, which became their limbs, revenged himself on those who had detained his wolves, and, having married the muskrat, by it peopled the world." ‡

In the Athapascan myth of the creation, the creative power takes the form of the raven. Brinton, quoting from McKenzie's "History of the Fur Trade," says: "With singular unanimity, most of the Northwest branches of this stock trace their descent from a raven, a mighty bird whose eyes were fire, whose glances were lightning, and the clapping of whose wings was thunder. On his descent to the ocean the earth instantly rose and remained on the surface of the water. This omnipotent bird then called forth all the variety of animals." §

And again: "A raven, also, in the Athapascan myth, saved their ancestors from the general flood, and in this instance it is distinctly identified with the mighty *Thunder Bird*, who, at the beginning, ordered the earth from the depths. Prometheus-like, it brought fire from heaven, and saved them from a second death by cold." ‖

A poetical description of this mythical bird has been given by Mr. Shelling, and is preserved in Griswold's collection of American poetry. We have room, however, for only a few lines of the poem:

* Pritchard, "Egyptian Mythology," p. 317.
† Pritchard, *op. cit.*, p. 319.
‡ Brinton, "Myths of the New World," p. 225.
§ Brinton, *op. cit.*, p. 211.
‖ Brinton, *op. cit.*, p. 220.

"About his burning brow a cloud,
Black as the raven's wing, he wore;
Thick tempests wrapped him like a shroud,
Red lightnings in his hand he bore;
Like two bright suns his eyeballs shone,
His voice was like the cannon's tone;
And, when he breathed, the land became,
Prairie and wood, one sheet of flame.

. . . .

"Afar on yonder faint-blue mound,
In the horizon's utmost bound,
At the first stride his foot he set;
The jarring world confessed the shock.
Stranger, the track of thunder yet
Remains upon the living rock." *

But besides the more ancient myths concerning crows and ravens, a volume might be filled with those *degraded* myths which, under the names of fairy-tales, or folk-lore (*Mährchen*), are found in all the languages of Europe; and though we can not follow each one, step by step, in its downward career, or trace all its varying phases with the same certainty that we can the metamorphosis of Odin into the wild huntsman of the Hartz, or the dethronement of Jupiter and his decretion into Jack the Giant-Killer, yet there are always preserved sufficient distinctive features by which their parentage can be traced.

In the Mecklenburg story of "The Three Crows," in the Grimms' collection, after Conrad had been beaten by his knavish companions until he was blind, and then robbed and tied to the gallows-tree, the three crows that perched over his head at night informed him how he could regain his sight, cure the sick princess, obtain a supply of water for the famishing town, and by so doing obtain the king's consent to marry the princess whom he had saved.†

We rarely discover in any one story so many of the mythological characteristics of the crow as are associated together here; the ill-omened gallows, the black night, the more than human wisdom of the crows, their knowledge of prophecy, and the healing art befitting Apollo's birds, their power of obtaining water, and lastly their malignant nature; for when Conrad's wicked companions sat under the gallows-tree, hoping to hear the crows tell something for their advantage also, the crows fell upon them with wings, beaks, and talons, and buffeted them until they were nearly dead.

In the story of "Faithful John," given in the same collection, we find the crows here also possessed of more than human wisdom in addi-

* A few miles from Big Stone Lake, on the borders of Minnesota and Dakota, there is seen an impression in the rock, similar to the imprint of a bird's foot, with the toes nearly a yard long; this track the Dakotas say is the footprint of the *Thunder Bird*.

† Grimms' "Popular Tales."

tion to the gift of prophecy. Faithful John, who understands the language of the crows, is enabled, by overhearing their colloquy, to save the lives of the prince and his bride; his motives, however, are misunderstood by his royal master, who sends him to the scaffold, whereupon he tells the prophecy of the crows and explains all his conduct; telling the secret, however, seals his fate, and while his master is begging forgiveness the faithful servant is turned into stone.*

This tale in varying forms is one of the most widely spread of all the stories of the Aryan tribes. Cox says it comes from the same source as the Deccan story of Rama and Luxman; and we find a somewhat erratic form of it in the touching little story of Prince Llewellyn and his faithful hound Gellert.

Philosophers at various times have attempted to account for this peculiar veneration of animals, which by many of the nations of antiquity was heightened into worship, and which, among some of the rude and barbarous tribes of Africa and the South-Sea Islands, still exists as almost their only recognition of a religion.† But a bare recital of the numberless theories would serve no good purpose, and draw out this article to unnecessary length. There are, however, two theories which not only seem plausible, but which seem to be supported by the facts of history and the practices of the savage tribes of the present day.

One is, that zoölatry is an outgrowth of a primitive worship of ancestors (necrolatry). The other is, that zoölatry as well as heliolatry, sabæanism, sex-worship, and probably other cults, are all derived from a primitive worship of the deified powers of nature (pantheism).

Though history affords many noted examples of the apotheosis of ancestors, and particularly in the patriarchal form of government, when the ancestor was also the ruler, yet it is only since the scientific study of ethnology has become general that the means have been afforded students of becoming acquainted on any extended scale with the crude and primitive beliefs of the lower races of man.

After the examination of a great mass of facts bearing upon the subject, Herbert Spencer arrives at the conclusion that the first ideas of ghosts or other supernatural beings have arisen in the mind of primitive man through the agency of dreams, somnambulism, trance, catalepsy, and other analogous conditions; and that the same conditions are continually reproducing the same ideas in the minds of his more civilized descendants. This *alter ego*, which exists in the dreams and visions of the primitive man, he believes also exists during the sleep of death; and that it is then more powerful than during life, and is able to perform not only all the vagaries and metamorphoses which he believes have actually occurred during sleep, but is also able to enter into and take possession of the bodies of animals, and even other human beings. As the vague notions of ghosts and spirits grow into

* Grimms' "Popular Tales."

† Sir John Lubbock, "Origin of Civilization," chap. v.

definiteness by the corroborating testimony of other members of the tribe, there would naturally arise a desire to gain the favor or avert the displeasure of these powerful beings by gifts and offerings similar to what would have given pleasure during life; these offerings would usually be made at the grave, cave, or house where the dead body was laid, and thus the tomb would become an altar or temple, as we see the tomb and temple associated even in civilized communities. In addition to the belief that the ghost of a dead ancestor or relative has the power to pass into the body of a beast, is the fact that the languages of the lower races of man are so imperfect that metaphorical names require to be interpreted literally, and consequently primitive speech is unable to transmit to posterity the slight shades of difference between an animal and a person named after that animal; moreover, having no knowledge of proper names, naming after animals, from some fancied resemblance or association of ideas, is most common, and hence we find such names as Black-Hawk, Little-Crow, Lone-Wolf, and Sitting-Bull. In the course of a few generations these animals would be looked upon as the ancestors of respective tribes, and would be reverenced and sacrificed to as deities. Besides explaining animal-gods, this hypothesis accounts for sundry anomalous beliefs, the divinities half-brute and half-human, the animals that talk and play active parts in human affairs, the doctrine of metempsychosis, etc.*

On the other hand, the pantheistic theory assumes that whatever caused the sentiment of awe, wonder, or fear, in the mind of primitive man, would be deified and worshiped; that the first objects that would excite these emotions would be the sun, moon, and stars, clouds, wind, rain, thunder, lightning, etc.; that from their ignorance of even the rudiments of physical science, together with the want of exactness of early language and its wealth of metaphor and personification, these cosmic objects and forces would be conceived of as individual entities, each having absolute personal volition: and since these metaphoric names would vary with the varying conception of each one of these fervent old pantheists, there would thus arise that almost endless polyonomy which has been the fertile source of so many of the myths that have puzzled and horrified mankind ever since their origin was forgotten. Moreover, since all metaphors depend upon some real or fancied resemblance of things less known to things better known, all of these deified powers of nature would be invested with forms and attributes similar to the animals and men with which they were already familiar, though in a magnified degree; and from this conception, by a very natural and usual transition of thought, the human or animal form, which had at first been sacred only as the *eidolon* of the god, would in a short time be thought to possess some intrinsic sanctity independent of that divine association.†

* Herbert Spencer, "Principles of Sociology," vol. i, chaps. xv to xxv.

† Cox, "Aryan Mythology," vol. i, chapters i to v.

There are many arguments in support of both of these theories, the chief objection being that either one alone is too exclusive to account for all the facts ; for, while there can be no doubt that ancestor-worship was the primitive and only religion of many, possibly all, the tribes of the earth at the dawn of their civilization, yet it is also certain that when tribes had formed settled communities, and a higher grade of culture had been attained, ancestor-worship was supplemented or supplanted by a worship of nature.

And since to primeval man none of the powers of nature seemed so beneficent or worthy of adoration as the sun, heliolatry was one of the most widely spread of all the religions of antiquity, and the daily conflict between the sun-god and clouds and darkness a never-ending theme for poet and priest. And as the incidents of these oft-repeated battles were handed down orally, from generation to generation, decked in all the glowing metaphors of exuberant fancy, the real nature of the deity they described and the celestial battles he waged would gradually be lost and forgotten, while the metaphoric names and metaphoric incidents would "survive the wreck of time" and come down to historic ages as actual incidents in the lives of real gods.

And it is in this mythological contest between the sun-god and the powers of darkness that we will find the origin of the demoniacal character of crows and ravens, these birds always representing in ancient thought the dark and terrible night, or the black and howling storm-cloud, the natural and necessary opponents of all that was bright and divine and good, of which the sun was the source and origin. Nor were these metaphors far-fetched or inappropriate, the darkness of night settling silently down over the calm, still earth might not inaptly be compared to the descent of some black gigantic bird ; and, to describe the fierce storm-cloud rushing through the sky "on the wings of the wind," no metaphor could be more exact than to liken it to a huge, ravening bird of prey. In most of the myths herein cited, the cloud seems to be the more exact equivalent of the bird, though in the earlier Hindoo mythology the cloud and the night are often convertible. The crow, as the metaphoric name of the cloud, also explains the connection of these birds with water, which we find not only in legends of the deluge but in many others.

The first Greek myth given is a degraded version of one of the numerous Hindoo myths of the god Indra, who slays the black dragon that has shut up the fertilizing waters : the *white* raven is the fleecy cloud of summer that contains no moisture ; but, as autumn advances and figs ripen, the cloud grows blacker and brings rain. It is worth noting, also, that the monstrous dragon of India shrinks into an insignificant water-snake when transported to the less rank soil of Hellas.

In the Greek myth quoted from Ovid, we have another of those widely-spread myths of the sun and dawn. Koronis (κορωνις) is the

beautiful (crown of light) Aurora, surprised by the morning cloud, the raven, in the embrace of another lover, the night.

In the Norse mythology the ravens that sit on Odin's shoulders are the clouds that are seen on either side of the rising sun. As the sun mounts higher and the heat increases, the clouds are dissipated, to return again in the evening when the air is cooler and the sun sinks into the western sea. The wolves have doubtless the same nebulous origin as the ravens; the name of one of them, *Freki*, most probably being a reminiscence if not a direct derivative of the Sanskrit *vrikas* (wolf), which, as we have before stated, in the Vedic hymns signifies the black night or the howling storm-cloud.

In the Semitic languages, from the prolific root *arab*, one of the meanings of which is *to be black*, was formed the Hebrew *oreb* (raven), *ereb* (evening, land of the setting sun), etc. From the same root also come *Erebos* and *Arabia;* hence, on linguistic grounds alone, it is impossible to decide whether Elijah was fed by the ravens or the Arabians.

The legend of Schamir is found in most of the languages of Europe, but in variously modified forms. In one place it is a stone, in another a worm, and in yet another it is a plant. Their agreement, however, in the power to rend rocks and to discover hidden treasures shows the origin of the myth to have been the storm-cloud which carries the thunderbolt, and with it rends the hardest rocks.

In the Egyptian mythology the reason assigned for dedicating the hawk to Horus is the bold flight which the bird is observed to make toward the sun without being dazzled by its rays; * but the reason for dedicating the crow to the same god is not so apparent, though it is probable that under the forms both of the wolf and the crow was represented the black night as an invariable and necessary follower of the god of day. Ælian says that in the temple of Apollo at Delphi was the statue of a wolf, and that the reason the wolf was sacred to this god was because he was born of Latona, or nursed by her, under this form.† It was doubtless a wolf of the same species that suckled the warlike twins of Silvia, at a later age, on the banks of the Tiber.

In both the Hindoo and the Greek mythologies we find the owl intimately associated with the crow—the owl, like the crow, being one of the demons of the night; but, as the owl was the representative of the bright night, or the moon, there was a constant warfare going on between them. The *Pancatantra* describes a battle between the owls and the crows, the *casus belli* being the opposition of the crows to the owl being elected king of birds. Aristotle, too, gravely informs us as a fact of natural history that "the crow and the owl also are enemies, for at mid-day the crow, taking advantage of the dim sight of the owl, secretly seizes and devours its eggs, and the owl eats those of the crow during the night." ‡

* Pritchard, *op. cit.*, p. 318. † Ælian, "Hist. Animal.," lib. x, chap. xx.

‡ Aristotle, "Hist. Animal.," lib. ix, chap. ii.

Whether an observance of the habits of crows led to their being selected, in the first place, to represent the dark and evil principle, can not now be told, but it is very certain that their feeding upon dead bodies, frequenting battle-fields and plague-infested districts, would add to and intensify their ominous reputation, even if it did not originate it; moreover, being constantly associated with death in its most repulsive forms, and from their keenness of scent and vision being able, apparently, to foretell the death of an animal or human being, their very presence soon came to be regarded as a foreboding of evil.

This keenness of scent and vision and their straight, vigorous flight were taken advantage of by the old Norse sea-rovers, who made use of these birds as pilots to guide them on their murderous forays and voyages of discovery. According to the "Landnama Book," one of the earliest records of Iceland, about the year 865 A. D., Floki, one of the most famous Vikings of that day, having performed a great sacrifice and consecrated three ravens to Odin, started from Norway on a voyage of discovery. After touching at the Shetland and Faroe Islands, Floki steered northwest for the open sea, and when he was fairly out of sight of land he turned loose one of his ravens, which, after rising to a great height, flew off toward the land they had left. From this Floki concluded that he was nearer these islands than any other land. After proceeding on his course some days longer he "let fly" another raven, which, after being some hours on the wing, returned to the vessel. Floki continued his course, and after a few days more let loose his third raven, and followed the direction of its flight until he reached the eastern coast of Iceland.

In Callimachus's hymn to Apollo, we also have mention of a pilot-crow being sent by the god to guide the tongue-tied Battus to Libya, where the Python had declared that he must found a colony. And, again, Plutarch tells, on the authority of Callisthenes, that when Alexander crossed the Libyan desert to consult the oracle of Jupiter Ammon, he was directed by a flock of crows, that suddenly made its appearance, and guided him on his way, flying briskly ahead when he was on the march, lighting when he halted, and, what is stranger still, when he was going wrong calling him by their croaking until he was in the right direction again. We might also mention, in this connection, the story Herodotus tells of the ubiquitous Aristeas, whom the Metapontines say appeared in their country, and told them to erect an altar to Apollo, and place near it a statue bearing the name of Aristeas the Prœonnesian, for Apollo had visited their country only of all the Italians, and that he who was now Aristeas had accompanied the god in the shape of a crow.

Another characteristic of crows is their longevity. Hesiod asserts that they will live nine times as long as a man, and it is certain that they have attained an age of more than one hundred years. On this account the sorceress Medea, with many other ingredients of a

peculiar nature, placed a crow's head and beak in the magic caldron when she was compounding the "elixir of life" to rejuvenate the decrepit Aeson.

Still another peculiarity of this family of birds is their human-like voice. All of them are easily domesticated, and nearly every variety can, without much trouble, be taught to speak. In some species, particularly the jabbering crow (*Corvus Jamaicensus*), their voices are so similar to those of human beings that, at a short distance, it is almost impossible to distinguish them apart.

But, while the ability to articulate probably first caused the crow to be regarded as a prophet, its evil habits, funereal associations, and metaphoric opposition to the sun-god caused it to be looked upon as a prophet only of evil, and as such it has always been regarded in mythology, legend, and popular tradition.

It seems curious that the figments of extinct mythologies should come from the dim and misty past, down through the ages, and still exist in the enlightenment of the present day; and yet we know that the *débris* of these effete religions not only survive in the legends and folk-lore of all the lands now civilized, but to a certain extent adulterate their manners and customs, their laws, and even their forms of religion.

A veneration for old manners and customs and the religion of his forefathers is imbibed by the child almost with his mother's milk; the sentiment grows with his growth and strengthens with his strength, until, when adult age is attained and the mind should be sufficiently mature to inquire into the truth and propriety of what he has been taught, the judgment has already become so prejudiced, by years of unquestioned obedience and unconscious imitation, that to defend and perpetuate even the errors and superstitions of his forefathers appears to him a solemn duty nearly akin to religion.

THE ELECTRIC BURGLAR-ALARM.

ELABORATE as are the ordinary agencies for the protection of property, they afford but a partial security. Well-lighted streets, careful watchmen, numerous policemen, and strong and ingeniously arranged bolts and bars, are certainly obstacles not easily overcome. But, in his quest of other men's riches, the accomplished burglar has not found them insurmountable. However extensive and vigilant a police force, it can not have all points under its surveillance at once, and this gives the burglar the opportunity which he rarely fails to improve. Bolts and bars are, doubtless, good things in their way; but the experienced cracksman has a cunning beyond them. In the contest between him and the locksmith, the victory has not always been with the latter, though he has produced that marvel of skill and

workmanship—the modern safe-lock. The burglar's tools are not such as are thwarted by nice mechanical combinations. Explosives and the simple mechanical powers in his hands have a wonderful range of utility, and are able to frequently set at naught the most elaborate contrivances. The protection afforded by these combined agencies is, however, only realizable to its full extent in the business centers of large cities. In resident districts, and in suburban and country situations where policemen are often few and far between, reliance has chiefly to be placed upon fastenings; and these often prove insufficient. Yet it is especially important to the owner of property that his protection be good, for recovery is very difficult. The advantages are so largely with the thieves, that they can frequently make the search a long and costly, and often a fruitless one. The cost is, in fact, the main bar to recovery. Only when stolen property is of large value does it pay to regain it. Small amounts, such as are usually taken from private houses, are practically irrecoverable.

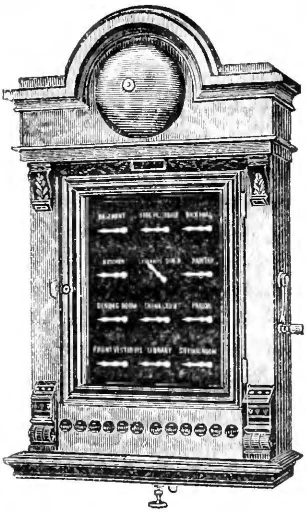
No practicable extension of the ordinary agencies can greatly increase present security. Bars and bolts have now approached very closely to their limit of strength and ingenuity, and police surveillance is as extensive and perhaps as effective as circumstances will permit. Greater protection must be sought in some further agency—one that will reproduce as nearly as possible the condition of watchfulness present in the daytime. This the electric burglar-alarm is designed to do, and does with a good degree of success. In its earlier forms there were many defects, but in a development of twenty years these have been mostly corrected. It has now attained to a simplicity of construction and certainty of action that make it one of the most useful and trustworthy of man's servitors. Though widely known and appreciated both in this country and abroad, there are probably many not acquainted with it, to whom a brief description will not be without value.

However the details of construction differ, the essential elements of every system are, a bell to give the alarm, an annunciator to indicate the point from which it proceeds, wires from all the openings of a building, and a battery to furnish the current. These elements are combined in various ways, depending upon the special circumstances of the particular case, but the manner of use is practically the same.

The main piece of apparatus, remarkable alike for the simplicity of its construction and the range of its performance, is the annunciator. In the earlier forms of the alarm, the indications were made by means of a simple switch-board provided with buttons bearing the names of the apartments protected. When an alarm sounded, the depression of each of these buttons in turn, until the bell ceased ringing, was necessary to determine its locality. This is still quite largely used, as it is cheaper than the more perfect annunciator, which tells at a glance where the disturbance in the circuit is. In shape and size this latter instrument resembles an ordinary mantel-clock. The indications are

given by devices on the face, which vary with different makers. In one form they are made by arrows, which lie horizontal when in normal position, and point to the names of the apartments printed above them when indicating. In another form, cards drop down in front of apertures arranged in rows on the face, and in still another the name and number of a room are uncovered by a falling piece when an alarm is sounded. The needle-instrument is shown in Fig. 1. Once made, the indications remain until the parts are restored by some one. A small switch at one side completes or opens the circuit through the instrument, and one on the other side controls the connection with the bell. A row of studs at the base of the apparatus allows any opening to be disconnected that may be desired. Aside from its giving an alarm when an attempt is made to enter a building, the annunciator has an important use in showing whether a place is properly closed. If any window or door has been forgotten, it will infallibly point it out. In large business houses where there are many openings, this feature is of the greatest value. By disconnecting the bell, this test can be made a silent one.

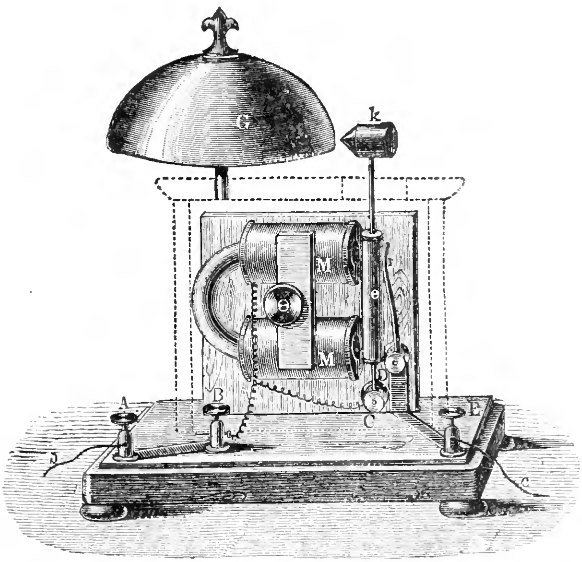
Fig. 1.



The mechanism operating the indicators is of the simplest description. In the needle-instrument, an arm on the pivot of the needle is held in position by the hooked end of a lever, the other end of which forms the armature of an electro-magnet. The connection between the lever and the supported arm is very slight, so that a small movement of the former allows the latter to fall. When the circuit is closed this takes place. The armature in moving toward the magnet raises the hooked end of the lever, releasing the arm which drops and turns its needle. In the instrument using the card, the card is carried on the end of an arm held up in a similar manner by a hook on the armature of the magnet. The depression of the armature allows the arm to drop by its weight. The restoring of the arms to position is done by a sliding frame raised by a handle or button on the base of the instrument. Delicate as the movements of the apparatus are, it is not easily put out of order. The points of contact of the hook and arm are so made as to reduce the wear to a minimum. The mechanism is all inclosed, and the exposed parts, such as the needles, switch-handles, etc., finished in polished metal. The annunciator and bell are usually combined into one piece of apparatus, but they may be put up separate when desired.

The bell used is that common with different forms of electrical instruments. It consists of a gong and a clapper vibrated by the combined action of an electro-magnet and a spring. The magnet, when the current passes, draws the clapper to itself and in doing so opens the circuit; this destroys its magnetism and allows the spring to carry the clapper back. This "make" and "break" action, rapidly repeated as long as the current is passing, produces a continuous ringing of the bell. Reference to Fig. 2 * will make this movement clear.

FIG. 2.



One end of the wire of the coils of the magnet M M is secured to the binding-post B, and the other to the post C. The arm of the clapper *k* is a rather stiff spring, which in its normal position holds the armature *e* carried by it from the poles of the magnet. It then presses against the spring *r*, attached to the post D. The posts A and E holding the wires from the battery are respectively connected with B and D by metallic strips. The current enters at A, traverses the coils of the magnet M M, passes through the armature *e*, and out by way of spring *r* and posts D and E. In doing so, the soft-iron cores of the magnet are magnetized and attract the armature *e*. This in moving breaks its contact with the spring *r*, and interrupts the current. The clapper then springs back into position. In the bell now generally used the ringing continues not only while the door or window is open, but until the indicating parts of the annunciator are restored to position.

* Figs. 2 and 3 are reproduced, through the kindness of Mr. George B. Prescott, from his works on "The Electric Light," etc., and "Electricity," etc.

This secures the proper resetting of the apparatus in readiness for a new alarm. The result is obtained very simply by making the clapper turn a switch, which cuts from the circuit the opened window or door, and allows the current to pass directly from the battery to the bell.

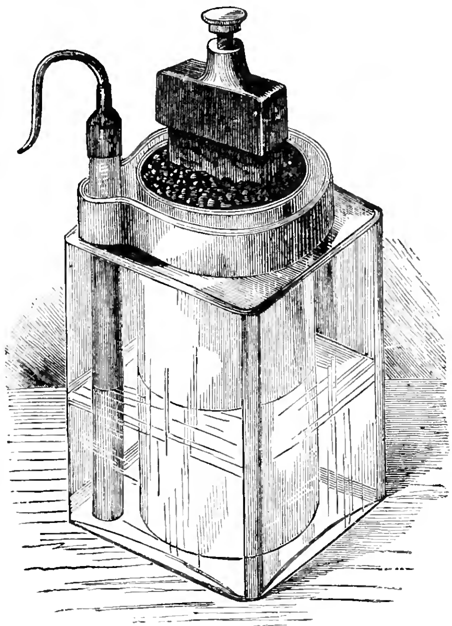
The door and window attachments for closing the circuit by the movements of these parts are of various forms. Those used on doors are simply little push-pins placed in the casing. The pin slides in an insulated case provided with metallic strips. When it is pressed in, the contact between it and the strips is broken and the circuit opened. When the pressure is released, the pin springs out, closing the circuit. The slightest movement of a door allows this motion of the pin to take place. In one form the pin and a metallic casing are so arranged that the attempt to keep the pin pushed in, when the door is opened, by inserting a knife-blade, establishes the circuit and gives the alarm. These push-buttons may be constructed to close the circuit, either by pushing in or springing out, and in both forms have a great variety of uses. They may be placed under the carpet, in the hall, on the stairs, in front of a window, or wherever any one entering would be liable to step. A sufficient number properly disposed could make intrusion without giving an alarm simply impossible. The window attachments are usually simple springs placed in the casing so that the movement of the sash presses them together. One form consists of a roller on the the end of a spring arm, which keeps it pressed out from contact with a metal strip, through which the circuit is completed. Placed in the casing, the roller stands out and is received in a pocket in the edge of the sash, so that the motion of the sash brings the roller arm and metal strip into contact. For the purpose of ventilation, the pocket in the upper sash is usually elongated to give a free movement through any desired distance. When the lower sash is left open, security can be gained by covering a push-pin in the window-sill with a flower-pot or other obstruction, the removal of which is necessary to gain entrance. The wires forming the circuit are of insulated copper, carefully put up so as to be completely hidden from view. They are run in grooves in the wood-work, carried beneath a floor, or on its face, according to circumstances. Once in place, they remain unchanged for any period, causing neither trouble nor expense.

The Le Clanché battery, shown in Fig. 3, is the one universally employed with this apparatus. It is very simple in construction, exhales no noxious gases when in operation, does not waste the material when no current is passing, and needs but very little attention. The positive pole is a piece of gas carbon placed in a porous cell filled with coarse-grained peroxide of manganese and carbon. The cell is sealed at the top with pitch, and a lead cap on the carbon receives the wire. The negative pole is formed of a rod of amalgamated zinc. Both poles are immersed in a solution of sal-ammoniac contained in a glass

jar. Four of these elements put up in a wooden case constitute the battery usually furnished.

These appliances provided, the most common way of using the system is to make it complete in each building, the alarm apparatus being placed in a sleeping-apartment in a private house, and in the

Fig. 3.



watchman's room in a place of business. So arranged, the condition of the circuit is this: In the daytime, when the doors and windows are open, the circuit is continuous at all points except at the alarm apparatus. At night this is reversed, the circuit being closed at the instrument, and broken at all the points protected. A movement at any of these points which closes the circuit gives the alarm and turns the proper needle on the annunciator. The connection with the alarm is made at night by an attendant, and broken at any desired time in the morning. In private houses fitted with electric bells, a clock is often provided that disconnects the alarm in the morning and turns the current on to a bell placed in the servants' room. The movement by which this is done is something similar to that of the ordinary alarm-clock.

The protection afforded with such an apparatus in good working order is probably as perfect as it can be made. It is generally impossible to cut the wires from the outside of the building, and unless this is done intrusion will start the alarm. Even if the wires be cut, but-

tons under the carpet or circuit-closers in interior doors will reveal the burglar's presence in perhaps every case.

Valuable as is the protection in any particular case of attempted robbery, the general immunity from such attempts that the presence of the apparatus secures is of still greater moment. Burglars will not generally take such risks as those imposed by an efficient alarm system, and will therefore give a house so protected a wide berth. The only case in which there is room for failure of the system is when the battery power is not sufficient to operate the alarm. But it is a very simple matter to provide against this. Tests once every month or two, and the experience soon gained in using the battery, will enable one to know at any time the state of the system. None of the other parts need ever cause any solicitude.

While in the great majority of cases the plan of giving the alarm to some one in the building broken into affords perfect security, in some it does not. In business centers, determined and cunning burglars, accustomed to take large chances, might frequently overpower the watchman and stop the alarm before it excited outside attention. To meet this difficulty the plan is sometimes adopted of making the alarm sound in a central office of the company furnishing the apparatus. One company doing this has adopted a system that seems to be beyond circumvention. Each building protected is connected on a closed circuit with the central office, at which place delicate galvanometers are used as indicators. The circuit of each building is independent of all others. Any change in the resistance of any circuit is instantly shown by the deflection of the proper needle, and an alarm started. The opening of a protected door or window breaks the circuit, as does the cutting of the line, and of course gives an alarm. If the burglar could carry the wire to the ground and insert just the proper resistance, no signal would be given at the company's office, but this is impossible, as the resistance is not only that of the wire but of the apparatus in circuit. The only way to get around it is to tunnel under the building, but even then circuit-breakers judiciously disposed would generally lead to detection. Nothing is gained, so far as the safe is concerned, in this case, as it is independently protected. It is placed in a light wooden cabinet lined with a metallic casing, consisting of two sheets of tin-foil insulated from each other by a thin sheet of non-conducting material. The wires from a battery are connected each with one of the sheets of foil. So delicate is the insulation that the sticking of a pin in the cabinet closes the circuit and deflects the needle, and sounds the alarm in the central office. This system, though not yet in extensive use, is gaining in favor among merchants having valuable stores of goods. A similar plan of protecting private houses whose occupants are away is practiced to some extent. The apparatus used in this case is much less delicate, and the protection therefore not so good.

The cost of applying the burglar-alarm to any house will vary in each case. It depends upon the size of the annunciator required and the number of openings to be protected. The prices charged by the different American manufacturers differ very little. Annunciators range in price from thirty dollars with four indications to one hundred dollars with twenty. The annunciator used should have as many indications as there are rooms protected. The cost of circuit-closers, including the placing in position and laying the wire, is three dollars a window when both sashes are connected. The same devices for doors vary from one and a half to two and a half dollars. In ordinary city houses it is only necessary to connect the windows and doors, front and back, of the first two stories and the opening in the roof. The entire cost will not generally exceed one hundred dollars. In the country the cost would of course be somewhat greater, in the average house probably between a hundred and fifty and two hundred dollars. The apparatus once in, the only expense is the maintenance of the battery. This will generally be very small, probably not more than a dollar a year. Considering the security gained, the outlay required is not excessive, and builders find that it is fully made up to them in increased rents. It is not improbable that the apparatus will eventually be considered as necessary to the complete equipment of a house as now are water- and gas-pipes.

Intimately connected with the burglar-alarm system, though having a different object, is an automatic fire-alarm, somewhat extensively introduced during recent years. The system consists in placing in the ceiling of a room a number of mercury bulbs, which close an electric circuit when the temperature rises above a certain point and set off an alarm. One form of the bulb or thermostat is shown in Fig. 4. The wire from the lower end is in permanent contact with the mercury, but that in the upper end comes in contact with it only when a given temperature is reached. The bulbs are usually manufactured to make this contact at a temperature of 120° Fahr. The thermostat is set in a bell-shaped shield of sheet-metal, only the rim of which, when in the ceiling, is exposed. They are placed about twenty feet apart in large rooms, a couple being sufficient for those of ordinary size. This alarm, like that for burglars, may be complete in a building, or may give its signal at a central office. In some of the larger cities this latter plan has been carried into practice. Each building is provided with an annunciator placed on the front, where it can be readily inspected. The signal given at the office indicates the building, and the annunciator on the face of the building gives the room in which the fire is located.

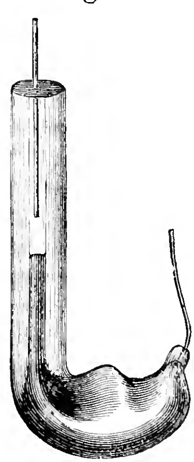


Fig. 4.—Thermostat.

Together these alarms form an excellent protection against the two most common dangers to which buildings and their contents are exposed. The addition of the call-bell system, now so common in hotels, business houses, and the better class of residences, completes an electrical equipment that leaves little to be desired in the way of security and convenience.

MENTAL IMAGERY.

By FRANCIS GALTON, F. R. S.

THERE are great differences in the power of forming pictures of objects in the mind's eye; in other words, of visualizing them. In some persons the faculty of perceiving these images is so feeble that they hardly visualize at all, and they supplement their deficiency chiefly by memories of muscular strain, of gesture, and of posture, and partly by memories of touch; recalling objects in the same way as those who were blind from their birth. Other persons perceive past scenes with a distinctness and an appearance of reality that differ little from actual vision. Between these wide extremes I have met with a mass of intermediate cases extending in an unbroken series.

We must establish clearly what we are talking about by contrasting in general terms the physiological basis of sight itself with that of sight-memory. Let us put the question to ourselves, "What should we expect to be the effect on our nervous system, first, when a sudden light is flashed on the eye, and, secondly, when we recall an image of that flash?" If we had means of watching what took place, we should no doubt be aware, in the first case, of a sudden irritation in the spread-out terminations of the optic nerve behind the retina. This would rapidly propagate itself along the nerve itself to the brain, where it would be distributed in various directions, becoming confused with other waves of irritation proceeding from independent centers, lingering here and there longer than elsewhere, and finally dying away.

In the recollection of a flash a similar sequence of events would take place, but they would occur in the *reverse order*. A variously distributed irritation in the brain, due to one or more of a multitude of possible causes, into which we need not stop to inquire, would propagate itself outward, becoming fainter the farther it traveled. The same links of the same nervous chain would be concerned in both cases, but the tension would be differently distributed among them. When the faculty of sight-memory is strong, the vigorous propagation of a central impulse toward the optic nerve must be habitual; when it is weak, the propagation will not take place except in peculiar states

of the nerves, as in dreams, in delirium, in high excitement, or under the influence of certain drugs.

These physiological considerations, vague as they are, will nevertheless suffice to establish the existence of a true kinship between mental imagery and ordinary vision. They enable us to define Shakespeare's phrase of seeing "with the mind's eye" as a condition in which the activity of the nervous center bears a higher ratio to that of the nervous terminations than it does in actual sight. They also justify us in ascribing the marked differences in the quality, as well as the vividness, of the mental imagery of different persons, to the various degrees in which the several links of a long nervous chain are apt to be affected.

The mental images of which I am about to speak are those which are habitually suggested by well-known associations. Even when the subject is thus limited, it is almost too large for the compass of a single memoir. Therefore, I shall do my best at present not to encroach upon that other very interesting branch of it, which treats of the visions and hallucinations that flash into view without any connection with the subjects of conscious thought. It is my purpose to point out the conditions under which mental imagery as above defined is most useful, and the particular forms of it which we ought to aim at developing; and I shall adduce evidence to show that the visualizing faculty admits of being educated, although no attempt has ever yet been made, so far as I know, to bring it systematically and altogether under control.

I draw my conclusions from no small amount of testimony. In addition to a large quantity of oral information of which I have made notes, I have received separate letters and replies by the hundred to a long list of questions which I circulated, besides obtaining batches of replies to the same questions from various schools. The answers, on the whole, have been written in a style that testifies to much careful self-analysis, and the general accordance of those that were derived from independent sources, together with the satisfactory way in which I have found many of the statements to bear cross-examination, has convinced me of their substantial truth.

I find the distribution of the visualizing faculty, in respect to its vividness, by a simple method I have described elsewhere.* I take a haphazard bundle of returns, mark them as an examiner would mark the papers of candidates, sort them in the order of their marks, and clip them into a portfolio. If I open the book in the middle I read the medium value; if I open it at one quarter from the beginning I read the highest quartile value; if at one quarter from the end, the lowest quartile. If I open it at one eighth of its thickness I read an octile value; and if at one sixteenth, a sub-octile.

* See an article by myself in "Mind" (July, 1880), p. 301, on "Statistics of Mental Imagery," and the references in the foot-notes to it.

Between the first and last quartiles extends the broad middle class. It includes the two middle quarters, or the central half of the population, whose characteristics are pretty uniform; it is at the beginning and end of the book that the exceptional cases lie in this, as in all other similar collections of statistics.

The medium quality of mental imagery among Englishmen may be briefly described as fairly vivid, but incomplete. The part of the picture that is well defined at any one moment is more contracted than it would be in a real scene; but, by moving the mental eye from point to point, the whole of the image, so far as it is remembered at all, may be successively brought into view. If this description be heightened a little, it will suit the high quartile; if it be lowered a little, it will suit the low quartile, so that with small variations it will apply to the whole of the middle class. When we arrive at the high and low octiles, the tenor of the returns is considerably changed; but we will pass by them and rest at the sub-octiles. At the highest of these the image is firm and clear, at the lowest there is scarcely any image at all.

This brief statement gives a scientifically exact idea of the distribution of the faculty among the inner fourteen in every sixteen Englishmen. I do not go further here, because I wish to specify the extent to which the faculty generally admits of being educated, and not to hold out ideals which are impossible of attainment except by very few. I shall submit direct evidence of what teaching can accomplish, but it will I am sure be allowed, in the mean time, that there is a probability of being able to educate a faculty among the great majority of men to the degree in which it manifests itself, without any education at all, in at least one person out of every sixteen. When speaking, as I shall soon do, of the various qualities of the faculty, I shall keep, as now, as far as possible to the commoner cases.

The power of visualizing is higher in the female sex than in the male, and is somewhat, but not much, higher in public-school boys than in men. I have, however, a few clear cases in which its power has greatly increased with advancing years. There is reason to believe that it is very high in some young children, who seem to spend years of difficulty in distinguishing between the subjective and objective world. Language and book-learning certainly tend to dull it.

The visualizing faculty is a natural gift, and, like all natural gifts, has a tendency to be inherited. In this faculty the tendency to inheritance is exceptionally strong, as I have abundant evidence to prove, especially in respect to certain rather rare peculiarities, of which I shall speak, and which, when they exist at all, are usually found among two, three, or more brothers and sisters, parents, children, uncles and aunts, and cousins.

Since families differ so much in respect to this gift, we may suppose that races would also differ, and there can be no doubt that such

is the case. I hardly like to refer to civilized nations, because their natural faculties are too much modified by education to allow of their being appraised in an off-hand fashion. I may, however, speak of the French, who appear to possess the visualizing faculty in a high degree. The peculiar ability they show in prearranging ceremonials and *fêtes* of all kinds and their undoubted genius for tactics and strategy show that they are able to foresee effects with unusual clearness. Their ingenuity in all technical contrivances is an additional testimony in the same direction, and so is their singular clearness of expression. Their phrase "figurez-vous," or "picture to yourself," seems to express their dominant mode of perception. Our equivalent of "imagine" is ambiguous.

It is among uncivilized races that natural differences in the visualizing faculty are most conspicuous. Many of them make carvings and rude illustrations, but only a few have the gift of carrying a picture in their mind's eye, judging by the completeness and firmness of their designs, which show no trace of having been elaborated in that step-by-step manner which is characteristic of draughtsmen who are not natural artists.

Among the races who are thus gifted are the despised, and, as I confidently maintain from personal knowledge of them, the much-underrated Bushmen of South Africa. They are no doubt deficient in the natural instincts necessary to civilization, for they detest a regular life, they are inveterate thieves, and are incapable of withstanding the temptation of strong drink. On the other hand, they have few superiors among barbarians in the ingenious methods by which they supply the wants of a difficult existence, and in the effectiveness and nattiness of their accoutrements. One of their habits is to draw pictures on the walls of caves, of men and animals, and to color them with ochre. These drawings were once numerous, but they have been sadly destroyed by advancing colonization, and few of them, and, indeed, few wild Bushmen, now exist. Fortunately, a large and valuable collection of fac-similes of Bushman art was made before it became too late, by Mr. Stow, of the Cape Colony, who has very lately sent some specimens of them to this country, in the hope that means might be found for the publication of the entire series. Among the many pictures of animals in each of the large sheets full of them, I was particularly struck with one of an eland, as giving a just idea of the precision and purity of their best work.

A small but interesting sheet of copies of Bushman drawings was presented by Colonel Moncrieff, C. B., of gun-carriage celebrity, to the Christie Collection, which is now incorporated with the British Museum. Many notices of them are to be found in Barrow's travels in South Africa, and elsewhere.

The method by which the Bushmen draw is described in the following extract from a letter written to me by Dr. Mann, the well-

known authority on South African matters of science. The boy to whom he refers belonged to a wild tribe living in caves in the Drakenberg, who plundered outlying farms, and were pursued by the neighboring colonists. He was wounded and captured, then sent to hospital, and subsequently taken into service. He was under Dr. Mann's observation in the year 1860, and has recently died, to the great regret of his employer, Mr. Proudfoot, to whom he became a valuable servant.

Dr. Mann writes as follows: "This lad was very skillful in the proverbial Bushman art of drawing animal figures, and upon several occasions I induced him to show me how this was managed among his people. He invariably began by jotting down, upon paper or on a slate, a number of isolated dots which presented no connection or trace of outline of any kind to the uninitiated eye, but looked like the stars scattered promiscuously in the sky. Having with much deliberation satisfied himself of the sufficiency of these dots, he forthwith began to run a free bold line from one to the other, and as he did so the form of an animal—horse, buffalo, elephant, or some kind of antelope—gradually developed itself. This was invariably done with a free hand, and with such unerring accuracy of touch that no correction of a line was at any time attempted. I understood from this lad that this was the plan which was invariably pursued by his kindred in making their clever pictures." It is impossible, I think, for a drawing to be made on this method unless the artist had a clear image in his mind's eye of what he was about to draw.

Other living races have the gift of drawing, but none more so than the Esquimau. I will therefore speak of these, and not of the Australian and Tasmanian pictures, nor of the still ruder performances of the old inhabitants of Guiana, nor of those of some North American tribes, as the Iroquois. The Esquimaux are geographers by instinct, and appear to see vast tracts of country mapped out in their heads. From the multitude of illustrations of their map-drawing powers, I will select one from those included in the journals of Captain Hall, at p. 224, which were published last year by the United States Government under the editorship of Professor J. E. Nourse. It is the fac-simile of a chart drawn by an Esquimau who was a thorough barbarian in the accepted sense of the word. That is to say, he spoke no language besides his own uncouth tongue, he was wholly uneducated according to our modern ideas, and he lived in what we should call a savage fashion. This man drew from memory a chart of the region over which he had at one time or another gone in his canoe. It extended from Pond's Bay, in lat. 73°, to Fort Churchill, in lat. 58° 44′, over a distance in a straight line of more than 960 nautical, or 1,100 English, miles, the coast being so indented by arms of the sea that its length is six times as great. On comparing this rough Esquimau outline with the Admiralty chart of 1870, their accordance is remarkable. I have seen many route maps

made by travelers in past years, when the scientific exploration of the world was much less advanced than it is now, and I can confidently say that I have never known of any traveler, white, brown, or black, civilized or uncivilized, in Africa, Asia, or Australia, who, being unprovided with surveying instruments, and trusting to his memory alone, has produced a chart comparable in extent and accuracy to that of this barbarous Esquimau. Their powers of accurate drawing are abundantly testified by the numerous illustrations in Rink's work, all of which were made by self-taught men, and are thoroughly realistic.

So much for the wild races of the present day ; but even the Esquimaux are equaled in their power of drawing by the men of old times. In ages so far gone by that the interval that separates them from our own may be measured in perhaps hundreds of thousands of years, when Europe was mostly ice-bound, a race, which in the opinion of all anthropologists was closely allied to the modern Esquimaux lived in caves in the more habitable places. Many broken relics of that race have been found ; some few of these are of bone, engraved with flints or carved into figures, and among these are representations of the mammoth, elk, and reindeer, which, if made by an English laborer with the much better implements at his command, would certainly attract local attention and lead to his being properly educated, and in much likelihood to his becoming a considerable artist.

It is not at all improbable that these prehistoric men had the same geographical instincts as the modern Esquimaux, whom they closely resemble in every known respect. If so, it is perfectly possible that scraps of charts scratched on bone or stone, of prehistoric Europe, when the distribution of land, sea, and ice was very different from what it is now, may still exist, buried underground, and may reward the zeal of some future cave explorer.

I now return to my principal topic, the mental imagery of the English race, and I will mention some of the chief peculiarities I have noted in it. When the faculty is strong it is apt to run riot. There are a few persons, including men and women of no mean capacity, who can not disentangle even the letters of the alphabet from the oddest associations with colors, formed in some half-forgotten period of childhood. To some of these persons it may be that an *a* will always convey the sense of blackness, an *e* that of greenness, an *i* will be blue, an *o* white, and a *u* red. The consonants will also for the most part have their separate tints, so that every word seems parti-colored to their fancy ; and a description of scenery in a book produces an effect upon their imagination very different from what the author could have foreseen. The same is true in respect to numerals, days of the week, and months of the year. I have collected perhaps twenty good accounts of these bizarre tendencies from independent sources, and find them to run strongly in families. They are not communicated by teaching or imitation, because those who have these peculiarities are usually

disinclined to talk about them, recollecting how they were laughed at on the few occasions when they did so. The fact of their being common to scattered members of the same family has often been discovered for the first time through my inquiries. I should say that I have found no general accordance between particular letters and colors. The relationship between them appears to be in each case a haphazard one ; but having been once formed it is durable.

Another and much more common oddity is the tendency to visualize numerals in a peculiar manner, which characterizes, as I have roughly reckoned, about one woman in every fifteen, and one man in every thirty. Those who do so are never able to dissociate any single number from its own particular place in the field of their mental view, so that when they think of a series of numbers they always visualize them in a certain form. Either the numbers are all visible at once, as if they were printed on cards and hung in space, according to some grotesque pattern, or the mind travels along a blank but familiar path to the place where the number that is thought of is known to reside, and then it starts into view. There are many weird varieties of this singular tendency to visualize numbers in forms, which I have lately described,* and will not here repeat. Suffice it to say, that they date from an earlier period than that to which recollection extends. They manifest themselves quite independently of the will ; they are invariably the same in the same person, but are never the same in two different persons, and the tendency to see them is strongly hereditary. I have now a collection of hundreds of them, not only from English men and women, boys and girls, but from American, French, German, Italian, Austrian, and Russian correspondents. They are found useful in the simpler kinds of mental arithmetic.

Those who see number-forms have usually some equally persistent scheme for dates, based more or less upon the diagrams of the schoolroom. I am well acquainted with an accomplished student of history whose mnemonic form for all historical events is a simple nursery diagram, which has blossomed, as it were, into large excrescences whereon the subsequently acquired facts are able to find standing-room. These diagrams are really helpful, because their shape is correlated with the subject they portray. They are not like the jingling nonsense verses and bad puns upon which many persons base their memory of facts.

The persistency of the forms under which numerals and dates are visualized testifies to a want of flexibility in mental imagery which is characteristic of many persons. They find that the first image they have acquired of any scene is apt to hold its place tenaciously in spite of subsequent need of correction. They find a difficulty in shifting their mental view of an object, and examining it at pleasure in differ-

* "Visualized Numerals," a Memoir read before the Anthropological Institute, March 9, 1880, about to be published in the forthcoming part of their journal of this year. See also a previous Memoir in "Nature," February 15, 1880.

ent positions. If they see an object equally often in many positions, the memories confuse one another. They are less able to visualize the features of intimate friends than those of persons of whom they have caught only a single glance. Many such persons have expressed to me their grief at finding themselves powerless to recall the looks of dear relations whom they had lost, while they had no difficulty in recollecting faces that were uninteresting to them.

Others have a complete mastery over their mental images. They can call up the figure of a friend, and make it sit on a chair or stand up at will; they can make it turn round and attitudinize in any way, as by mounting it on a bicycle or compelling it to perform gymnastic feats on a trapeze. They are able to build up elaborate geometric structures bit by bit in their mind's eye, and add, subtract, or alter at will and at leisure. This free action of a vivid visualizing faculty is of much importance in connection with the higher processes of thought, though it is commonly abused, as may be easily explained by an example. Suppose a person suddenly to accost another with the following words: "I want to tell you about a boat." What is the idea that the word "boat" would be likely to call up? I tried the experiment with this result. One person, a young lady, said that she immediately saw the image of a rather large boat pushing off from the shore, and that it was full of ladies and gentlemen, the ladies being dressed in white and blue. It is obvious that a tendency to give so specific an interpretation to a general word is absolutely opposed to philosophic thought. Another person, who was accustomed to philosophize, said that the word "boat" had aroused no definite image, because he had purposely held his mind in suspense. He had exerted himself not to lapse into any one of the special ideas that he felt the word boat was ready to call up, such as a skiff, wherry, barge, launch, punt, or dingy. Much more did he refuse to think of any one of these with any particular freight or from any particular point of view. A habit of suppressing mental imagery must, therefore, characterize men who deal much with abstract ideas; and, as the power of dealing easily and firmly with these ideas is the surest criterion of a high order of intellect, we should expect that the visualizing faculty would be starved by disuse among philosophers, and this is precisely what I have found on inquiry to be the case.

Here, however, a fresh consideration comes in, which shows that the tendency to visualize is liable to be over-corrected, especially by those who are accustomed but not obliged to visualize in hard and persistent forms, and that they lose thereby the only means of obtaining a correct mental picture of a species or race. I proved two years ago* that a generalized picture did as a matter of fact admit of being produced. I threw magic-lantern portraits of different persons on the top

* "Journal Anthropological Institute," "Composite Portraits," vol. viii, 1878, p. 132. "Journal Royal Institution," "Generic Images," ix, 1879, p. 161.

of one another, on the same screen, and elicited a resultant face which resembled no one of the components in particular, but included all. Whatever was common to all the portraits became intensified by combination; whatever was peculiar to each portrait was relatively too faint to attract attention, and virtually disappeared. I made a great variety of experiments; in some I optically superimposed images by arrangements of lenses, mirrors, stereoscopes, or doubly refracting crystals; in others I combined separate photographic impressions upon a single sensitized plate. The result was that I invariably found it possible to make a generalized picture, having a remarkable appearance of individuality, out of a collection of separate portraits, so long as the latter bore a moderate resemblance to one another, and were taken from the same point of view, and were of the same size.

I argue that the mind of a man whose visualizing faculty is free in its action forms these generalized images of its own accord out of its past experiences. It readily reduces images to the same scale, through its constant practice in watching objects as they approach or recede, and consequently grow or diminish in size. It readily shifts images to any desired point of the field of view, through its habit of following bodies in motion to the right or left, upward or downward. It selects images that present the same aspect, either by a simple act of memory or by a feat of imagination that forces them into the desired position, and it has little or no difficulty in reversing them from right to left, as if seen in a looking-glass. In illustration of these generalized mental images let us recur to the boat, and suppose the speaker to continue as follows: "The boat was a four-oared racing boat; it was passing quickly just in front of me, and the men were bending forward to take a fresh stroke." Now, at this point of the story the listener ought to have a picture well before his eye. It ought to have the distinctness of a real four-oar going either to the right or the left, at the moment when many of its details still remained unheeded, such as the dresses of the men and their individual features. It would be the generic image of a four-oar formed by the combination into a single picture of a great many sight-memories of those boats.

In the highest minds a descriptive word is sufficient to evoke crowds of shadowy associations, each striving to manifest itself. When they differ so much from one another as to be unfit to combine into a single idea, there will be a conflict between them, each being prevented by the rest from obtaining sole possession of the field of consciousness. There would, therefore, be no definite imagery so long as the aggregate of all the pictures that the word could reasonably suggest, of objects presenting similar aspects, reduced to the same size, and accurately superposed, resulted in a mere blur; but a picture would gradually evolve as qualifications were added to the word, and it would attain to the distinctness and vividness of a generic image long before the word had been so restricted as to be individualized. If the intellect be slow,

though correct in its operations, the associations will be few, and the generalized image based on insufficient data. If the visualizing power be faint, the generalized image will be indistinct.*

Some persons have the power of combining in a single perception more than can be seen at any one moment by the two eyes. It is needless to insist on the fact that all who have two eyes see stereoscopically, and therefore somewhat round a corner. Children, who can focus their eyes on very near objects, must be able to comprise in a single mental image much more than a half of any small thing they are examining. Animals such as hares, whose eyes are set more on the side of the head than ours, must be able to perceive at one and the same instant more of a panorama than we can. I find that a few persons can, by what they often describe as a kind of touch-sight, visualize at the same moment all round the image of a solid body. Many can do so nearly, but not altogether, round that of a terrestrial globe. An eminent mineralogist assures me that he is able to imagine simultaneously all the sides of a crystal with which he is familiar. I may be allowed to quote my own faculty in this respect. It is exercised only occasionally and in dreams, but under those circumstances I am perfectly conscious of embracing an entire sphere in a single perception.

This power of comprehension is practically attained in many cases by indirect methods. It is a common feat to take in the whole surroundings of an imagined room with such a rapid mental sweep as to leave some doubt whether it has not been viewed simultaneously. Some persons have the habit of viewing objects as though they were partly transparent; thus they can see the north and south poles of a globe, but not the equatorial parts, at the same time. They can also see into all the rooms of an imaginary house by a single mental glance. A fourth class of persons have the habit of recalling scenes, not from the point of view whence they were observed, but from a distance, and they visualize their own selves as actors on the mental stage. By one or other of these ways, the power of seeing the whole of an object, and not merely one aspect of it, is attained by many persons, and might probably be attained by all.

A useful faculty, easily developed by practice, is that of retaining a mere retinal picture. A scene is flashed upon the eye; the memory of it persists, and details which escaped observation during the brief time when it was actually seen may be analyzed and studied at leisure in the subsequent vision.

The place where the image appears to lie differs much in different persons. Most see it in an indefinable sort of way, others see it in front of the eye, others at a distance corresponding to reality. There exists a power which is rare naturally, but can, I believe, be easily

* It may possibly interest some persons, in connection with this topic, to refer to my "Psychometric Facts," in the "Popular Science Monthly" for April, 1879.

taught, of projecting a mental picture upon a piece of paper, and of holding it fast there, so that it can be outlined with a pencil. The Bush-boy of whom I spoke must have had something of this faculty.

We may now foresee that education is likely to accomplish much, for most of the more important peculiarities of which I have spoken are naturally present in a high degree in at least one person out of sixteen. It can hardly be doubted that any of these might be developed by education to a useful amount in, say, twelve out of the remaining fifteen (thus raising all who ranked above the lowest quartile to at least the level of the highest sub-octile).

The forms of the visualizing faculty which we ought to aim at producing appear to me to be as follows:

The capacity of calling up at will a clear, steady, and complete mental image of any object that we have recently examined and studied. We should be able to visualize that object freely from any aspect; we should be able to project any of its images on paper and draw its outline there; we should further be able to embrace all sides of the object simultaneously in a single perception, or at least to sweep all sides of it successively with so rapid a mental glance as to arrive at practically the same result. We ought to be able to construct images from description or otherwise, and to alter them in whatever way we please. We ought to acquire the power of combining separate, but more or less similar, images into a single generic one. Lastly, we should learn to carry away pictures at a glance of a more complicated scene than we can succeed at the moment in analyzing.

There is abundant evidence that the visualizing faculty admits of being largely developed by education. The testimony on which I would lay especial stress is derived from the published experiences of M. Lecoq de Boisbaudran, late Director of the École Nationale de Dessin, in Paris, which are related in his "Éducation de la Mémoire Pittoresque." * He trained his pupils with extraordinary success, beginning with the simplest figures. They were made to study the models thoroughly before they tried to draw them from memory. One favorite expedient was to associate the sight-memory with the muscular memory, by making his pupils follow at a distance the outlines of the figures with a pencil held in their hands. After three or four months' practice, their visual memory became greatly strengthened. They had no difficulty in summoning images at will, in holding them steady, and in drawing them. Their copies were executed with marvelous fidelity, as attested by a commission of the Institut, appointed in 1852 to inquire into the matter, of which the eminent painter, Horace Vernet, was a member. The present Slade Professor of Fine Arts at University College, M. Légros, was a pupil of M. de Boisbaudran. He has expressed to me his indebtedness to the system, and he has assured me of his own success in teaching others in a similar way.

* Republished in an 8vo, entitled "Enseignement Artistique." Morel et Cie. Paris, 1879.

I could mention instances within my own experience in which the visualizing faculty has become strengthened by practice ; notably one of an eminent engineer, who had the power of recalling form with unusual precision, but not color. A few weeks after he had replied to my questions, he told me that my inquiries had induced him to practice his color memory, and that he had done so with such success that he had become quite an adept at it, and that the newly acquired power was a source of much pleasure to him.

The memories we should aim at acquiring are chiefly such as are based on a thorough understanding of the objects observed. In no case is this more surely effected than in the processes of mechanical drawing, where the intended structure has to be portrayed so exactly in plan, elevation, side view, and sections, that the workman has simply to copy the drawing in metal, wood, or stone, as the case may be. It is undoubtedly the fact that mechanicians, engineers, and architects possess the faculty of seeing mental images with remarkable clearness and precision.

A few dots like those of the Bushmen give great assistance in creating an imaginary picture, as proved by our general habit of working out new ideas by the help of marks and rude lines. The use of dolls by children also testifies to the value of an objective support in the construction of mental images. The doll serves as a kind of skeleton for the child to clothe with fantastic attributes, and the less individuality the doll has, the more it is appreciated by the child, who can the better utilize it as a lay figure in many different characters. The art of strengthening visual as well as every other form of memory lies in multiplying associations ; the healthiest memory being that in which all the associations are logical, and toward which all the senses concur in their due proportions. It is wonderful how much the vividness of a recollection is increased when two or more lines of association are simultaneously excited.

It is a mistake to suppose that a powerful exercise of the will can vivify a faint image. The action of the will is negative, being limited to the suppression of what is not wanted and would be in the way. It can not create thought, but it can prevent thoughts from establishing themselves which lead in a false direction ; so it keeps the course clear for a logical sequence of them. But, if appropriate ideas do not come of their own accord, the will is powerless to evoke them. Thus, when we forget a familiar name, it is impossible to recall it by force of will. The only plan in such cases is to think of other things, till some chance association suggests the name. The mind may be seriously dulled by over-concentration, and will only recover its freshness by such change of scene and occupation as will encourage freedom and discursiveness in the flow of the ideas.

All that remains to be said refers to the utility of the visualizing faculty, and may be compressed into a few words. A visual image is

the most perfect form of mental representation wherever the shape, position, and relations of object in space are concerned. It is of importance in every handicraft and profession where design is required, because workmen ought to visualize the whole of what they propose to do before they take a tool in their hands. Thus, the village smith and the carpenter, who are employed on odd jobs, require it no less for their work than the mechanician, the engineer, and the architect. The lady's-maid who arranges a new dress requires it for the same reason as the decorator employed on a palace, or the agent who lays out great estates. Strategists, artists of all denominations, physicists who contrive new experiments, and, in short, all who do not follow routine, have need of it. The pleasure its use can afford is immense. I have many correspondents who say that the delight of recalling beautiful scenery and great works of art is the highest that they know. Our bookish education tends unduly to repress this valuable gift of nature. A faculty that is of importance in all technical and artistic occupations, that gives accuracy to our perceptions, and justness to our generalizations, is starved by disuse, instead of being cultivated in the way that will bring most return. I believe that a serious study of the best method of developing the faculty of visualizing is one of the many pressing *desiderata* in the new science of education.—*Fortnightly Review.*

HENRY AND FARADAY.*

By Professor ALFRED M. MAYER.

MOST reluctantly do I here desist from citing further the works of Henry. It is impossible to crowd into one brief hour the thoughts which were his occupation during more than half a century. I have at least endeavored to exhibit before you the more important of the labors of his life. What shall we think of them? Surely they are on as high a plane as those of any of his contemporaries, and show as much originality as theirs in their conception—as much skill in their execution. Yet it has been said that Henry was not a man of genius. As I have not been able to find that the philosophers, who have the special charge of giving from time to time definitions of genius, have been able to come to any satisfactory conclusion among themselves, I will leave their company, and, with your liberty, take my definition from a book which, if we accredit Thackeray, is one of the very best, if not the best, novel ever writ in English. After listening to this I will allow you to form your own opinions as to whether Henry did or did not possess genius: "By genius I would understand that power,

* Extract from "Henry as a Discoverer," a paper read by Professor Mayer at the recent Boston meeting of the American Scientific Association.

or rather those powers of the mind which are capable of penetrating into all things within our reach and knowledge, and of distinguishing their essential differences. These are no other than invention and judgment; and they are both called by the collective name of genius, as they are of those gifts of nature which we bring with us into the world. Concerning each of which, many seem to have fallen into very great errors; for by invention, I believe, is generally understood a creative faculty, which would indeed prove most romance writers to have the highest pretensions to it; whereas by invention is meant no more (and so the word signifies) than discovery or finding out; or, to explain it at large, a quick and sagacious penetration into the true essence of all the objects of our contemplation. This, I think, can rarely exist without the concomitancy of judgment, for how we can be said to have discovered the true essence of two things, without discerning their difference, seems to me hard to conceive. Now, this last is the undisputed province of judgment; and yet some few men of wit have agreed with all the dull fellows in the world in representing these two to have been seldom or never the property of one and the same person."

My own judgment, if of any value, would rank the ability of Henry—I do not say his achievements—a little below that of Faraday. Indeed, their lives and their manners of working were strangely alike. Each started in life with moral and benevolent habits, well developed and healthy bodies, quick and accurate perceptions, calm judgment and self-reliance, tempered with modesty and good manners—a good ground, surely, in which to plant the germs of the scientific life. Faraday was an apprentice to a bookbinder. Henry served in the same capacity under a silversmith. Each, endowed with a lively imagination, was in his younger days fond of romance and the drama; and, by a singular similarity of accidents, each had had his attention turned to science by a book which chance threw in his way. This work, in the case of Faraday, was Mrs. Marcet's "Conversations on Chemistry," and the book which influenced Henry's career was Gregory's "Lectures on Experimental Philosophy, Astronomy, and Chemistry." Of Mrs. Marcet's book Faraday thus writes:

My dear Friend: Your subject interested me deeply every way; for Mrs. Marcet was a good friend to me, as she must have been to many of the human race. I entered the shop of a bookseller and bookbinder at the age of thirteen, in the year 1804, remaining there eight years, and during the chief part of the time bound books. Now, it was in those books, in the hours after work, that I found the beginning of my philosophy. There were two that especially helped me, the "Encyclopædia Britannica," from which I gained my first notions of electricity, and Mrs. Marcet's "Conversations on Chemistry," which gave me my foundation in that science.

Do not suppose that I was a very deep thinker, or was marked as a precocious person. I was a lively, imaginative person, and could believe in the "Arabian Nights" as easily as in the "Encyclopædia." But facts were important

to me and saved me. I could trust a fact, and always cross-examined an assertion. So, when I questioned Mrs. Marcet's book, by such little experiments as I could find means to perform, and found it true to the facts as I could understand them, I felt that I had got hold of an anchor in chemical knowledge, and clung fast to it. Thence my deep veneration for Mrs. Marcet—first as one who had conferred great personal good and pleasure on me; and then as one able to convey the truth and principle of those boundless fields of knowledge which concern natural things to the young, untaught, and inquiring mind.

You may imagine my delight when I came to know Mrs. Marcet personally; how often I cast my thoughts backward, delighting to connect the past and present; how often, when sending a paper to her as a thank-offering, I thought of my first instructress, and such thoughts will remain with me.

Henry wrote on the inside of the cover of Gregory's work the following words:

This book, although by no means a profound work, has, under Providence, exerted a remarkable influence on my life. It accidentally fell into my hands when I was about sixteen years old, and was the first book I ever read with attention. It opened to me a new world of thought and enjoyment; invested things before almost unnoticed with the highest interest; fixed my mind on the study of nature, and caused me to resolve at the time of reading it that I would immediately commence to devote my life to the acquisition of knowledge. J. H.

Each of these philosophers worked with simple instruments mostly constructed by his own hands, and by methods so direct that he appeared to have an almost intuitive perception into the workings of nature; and each gave great care to the composition of his writings, sending his discoveries into the world clothed in simple and elegant English.

Finally, each loved science more than money, and his Creator more than either.

There was sympathy between these men, and Henry loved to dwell on the hours that he and Bache had spent in Faraday's society. I shall never forget Henry's account of his visit to King's College, London, where Faraday, Wheatstone, Daniell and he had met to try and evolve the electric spark from the thermopile. Each in turn attempted it and failed. Then came Henry's turn. He succeeded; calling in the aid of his discovery of the effect of a long inter-polar wire wrapped around a piece of soft iron. Faraday became as wild as a boy, and, jumping up, shouted, "Hurrah for the Yankee experiment!"

And Faraday and Wheatstone reciprocated the high estimation in which Henry held them. During a visit to England, not long before Wheatstone's death, he told me that Faraday and he had, after Henry's classical investigation of the induced currents of different orders, written a joint letter to the council of the Royal Society, urging that the Copley medal, "that laurel-wreath of science," should be bestowed on Henry. On further consultation with members of the council, it

was decided to defer the honor till it would come with greater *éclat*, when Henry had continued further his researches in electricity. Henry's removal to Washington interrupted these investigations. Wheatstone promised to give me this letter, to convey to Henry as an evidence of the high appreciation which Faraday and he had for his genius; but Wheatstone's untimely death prevented this. Both Faraday and Henry gave much thought to the philosophy of education, and in the main their ideas agreed. I may, in this connection, be excused for reading abstracts from a letter from Henry soon after he had received the news that I had given my son his name. In this letter he gives this information, which may be news to the most of you:

> I did not object to Henry as a first name; although I have been sorry that my grandfather, in coming from Scotland to this country, substituted it for Hendrie, a much less common, and, therefore, distinctive name.

He then proceeds:

> I hope that both his body and his mind will be so developed by proper training and instruction that he may become an efficient, wise, and good man. I say efficient and wise, because these two characteristics are not always united in the same person. Indeed, most of the inefficiency of the world is due to their separation: wisdom may know what ought to be done, but it requires the aid of efficiency to accomplish the desired object. I hope that in the education of your son due attention may not only be given to the proper development of both these faculties, but also that they will be cultivated in the order of nature: that is, doing before thinking; art before science. By inverting this order much injury is frequently done to a child, especially in the case of the only son of a widowed mother, in which a precocious boy becomes an insignificant man. On examination in such a case, it will be generally found that the boy has never been drilled into expertness in the art of language, of arithmetic, or of spelling, of attention, perseverance, and order, or, in other words, of the habits of an active and efficient life.

Henry was a man of extensive reading, and often surprised his friends by the extent and accuracy of his information, and by the original manner in which he brought his knowledge before them. Not only was he well versed in those subjects in which one might naturally suppose him proficient, but in departments of knowledge entirely distinct from that in which he gained his reputation as an original thinker. Although without a musical ear, he had a nice feeling for the movement of a poem, and was fond of drawing from his retentive memory poetic quotations apt to the occasion. He was a diligent student of mental philosophy, and also took a lively interest in the progress of biological science, especially in following the recent generalizations of Darwin, while the astonishing development of modern research in tracking the history of prehistoric man had for him a peculiar fascination. Yet, with all his learning, reputation, and influence, Henry was as modest as he was pure.

One day, on opening Henry's copy of Young's "Lectures on Natu-

ral Philosophy"—a book which he had studied more than any other work of science—I read on the fly-leaf, written by his own hand, these words:

> "In Nature's infinite book of secrecy
> A little I can read."—*Shakespeare.*

And did he not read a little "in Nature's infinite book of secrecy"? and did he not read that little carefully and well? May we all read our little in that book as modestly and as reverently as did Joseph Henry!

THE EVOLUTION OF ORGANIC FORM.

By CHARLES MORRIS.

WHAT does the story of life upon the earth teach us concerning the unfoldment of organic form? Is the human figure a chance result of an evolutionary force which might have pursued some quite different direction; or are the laws of development such as to lead inevitably toward the form of man as their highest organic product? This is a question admitting of a more definite answer than may at first thought appear, as we hope to show by a rapid survey of the various steps of the process.

And, first, it must be borne in mind that Nature's efforts at animal and plant formation have been on no contracted scale. The varying forms produced have been almost multitudinous. They exist at present in the greatest variety. But the present is only the apex of a long succession of life-epochs, each with its special organic group. We must multiply the existing forms by thousands of such epochs to obtain any adequate idea of the whole broad field of life. Plainly, then, Nature has not dealt sparsely with the subject, but has produced a most generous profusion of differing forms. Hence, narrow as is the field of the earth, there is reason to believe that the form-evolving principle has had full opportunity here to act, and that it has selected out the most favorable line of development from the many directions attempted.

Life is an incessant battle—a battle for food, and a battle for safety. The total quantity of food is limited. The powers of organic increase are unlimited. Thus a fight for food becomes necessary; a conflict in which no quarter is asked and none given. Victory inclines to the strongest and best armed. The successful combatant must have powers of defense against all Nature's attacks, and of assault against all Nature's defenses. In other words, the organism best adapted to its environment will win.

And this incessant weeding-out process is not confined to mature

forms. It is constantly in action, from the germ up to maturity. There is as fierce a battle between germs as between grown animals as to which shall survive. The ill-adapted embryo perishes; the well-adapted lives. Of the multitudes of young, only those survive which are best fitted to obtain food and escape peril. There is thus a succession of conditions to which the growing form must be successively adapted, and each mature form is the sole survivor of a myriad of germs which started together in the race of life. It has been sharply selected out as the best adapted.

The law of adaptation thus works vigorously throughout all embryonic development. It works as decisively on mature forms. They must be closely adapted to certain conditions of nature; but the possible variation in conditions is almost boundless. Not only in time have there been constant changes in natural conditions, and not only do they now widely vary in different localities, but even in the same locality a great variety of differing conditions simultaneously exist.

As the simple atoms of the chemical elements unite to form complex compounds, so do simple conditions unite into complex. Numerous sets of minor conditions exist together, from whose combination are formed less numerous major conditions, and from these again a single highest condition which includes all below its level. Thus each locality may possess its many sets of simpler forms, and sets of superior forms narrowing in number as they become adapted to a wider environment, until a highest or most complex form is reached, which is in physical harmony with the totality of existing conditions.

And the question of superiority and inferiority between animals is simply a question of the greater or lesser complexity of the conditions to which they are fitted, the broader or narrower field of adaptation which they occupy.

But, in this quick pressing of new forms into every nook and cranny of nature, there are certain general principles which have a controlling influence over the resulting changes in form. One consideration must always be taken into account, that of the character of organic material—of protoplasm—and the forms it naturally tends to assume. And a second consideration is that of the main end of animal life—the absorption of aliment. From this latter it follows that the basic type of animal form is the stomach; and in viewing the field of animal development we behold only a series of stomachs, provided with various food-taking and danger-escaping appendages.

Evolution, then, means the gaining of superior powers of providing for the needs of this voracious core of all animals, the stomach; and of superior powers of escaping the voraciousness of other armed and perambulatory stomachs.

The aliment on which organisms subsist is of three kinds—mineral, vegetable, and animal. The pursuit of these yields two distinct classes of organisms. Mineral food needs to undergo a high degree of chemi-

cal integration. The organisms which subsist upon it are functionally low, the forces which might have been otherwise employed being used up in the formation of protoplasm and other high organic compounds.

The conditions of alimentation limit the vegetable world to one general form. Plants do not need to seek food; food seeks them. Thus no motive powers are requisite, and they remain fixed in one position. But food seeks them in two different localities, the earth and the air. The earth constituent comes to them dissolved in water, the atmospheric constituent dissolved in air. They must, therefore, have powers of extension sufficient to occupy both these fields. This power is obtained by growth, root-extension seeking the liquid food, leaf-extension the gaseous food.

These general conditions confine plants to one generic form, a connecting link of stem between earth and air, and an extension of root-mouths into the soil and of leaf-mouths into the atmosphere. A tree is a society, or family; the main stem being the patriarch of the flock, the earth and air branches its descendants, and the leaves and rootlets its latest unisexual offspring.

As the type of animal form is the stomach, so the type of plant form is the mouth. It has not yet developed into the formation of a central stomach, nor has it attained powers of digestion. It builds up protoplasm by successive steps of chemical integration. It is a laboratory for the production of chemical synthesis—not of chemical analysis, as in animals.

Thus the food-taking requisite is provided for in the production of numerous leaf and root mouths, extending themselves into the two great reservoirs of food. But defense must be provided for as well. Plants are attacked by various foes. Fierce storms assail them. These can only be resisted by an inmate strength or elasticity. Wintry cold congeals their food-supply. They must therefore be capable of hibernating. Animals seek to devour them. They can only escape by inclosing themselves in a rigid armor, or by becoming unfitted for animal food.

This leads us to the most significant adaptation in plants. Their life duration is limited, and they must have powers of reproduction, the best adapted in this respect crowding out the less adapted. Obviously the seed-bearers are best fitted for survival; and of these, those bearing the most seeds, and having the best facilities for dispersing them.

But the fixed plant can not, of itself, spread its seeds beyond its own locality. It must be aided by other agencies. Many plants avail themselves of air-currents for this purpose, the seeds being provided with curious appendages to aid them in flying or rolling before the winds. In other cases the seed is surrounded by a store of palatable food, offering an inducement to the higher animals to devour it, and thus to disseminate the seeds.

Fertilization of the flowers is provided for in a similar manner. The flowers can not reach each other, and therefore enlist insects in their aid, preparing a store of food highly palatable to these air rovers, and thus having their fertilizing germs carried from flower to flower.

Such are the general agencies at work in plant-life, and producing its typical form. And thus, while protecting their vital organs by a rigid armor, plants provide for reproduction by adapting a portion of their bodies for animal food ; gaining in this manner for their offspring the powers of motion which they lack themselves.

Yet all plants are not confined to this typical form, as all plants are not confined to purely inorganic aliment. Some subsist on partly or fully elaborated organic food, and these deviate from the plant and approach some of the animal types of form, which we have next to consider.

In animal life very different requirements from those presented by plants are exhibited, and the forms are essentially different. Yet their main functions are the same. All organisms are adapted to the two general purposes of food-getting and defense, to which all their other powers are subordinate.

As vegetables subsist on mineral, so animals subsist on organic food, either vegetable or animal. And this food presents another essential difference from that of plants. It exists only in the solid state, while that of plants is wholly fluid. It can not be taken by direct imbibition, like that of vegetables, but must be first rendered liquid through some digestive process, and afterward imbibed. Thus an internal stomach is necessary to all but the very lowest animals, and even these improvise temporary stomachs, which foreshadow the permanent stomach.

The animal—not being bathed in an ocean of food, which it has but to drink in at a multitude of mouths covering its whole periphery, as in the plant—must have means of drawing food to it, or organs enabling it to go in search of food. In short, it must have motive powers.

And for those creatures which are obliged to go in search of their food, it is equally requisite that they should be able to discover its locality. Sensory organs, therefore, become necessary. Consequently, the animal is superior to the plant through this possession of muscular and sense organs. It is also superior in being able to employ the energy derived from its food, not in the building up of chemical compounds, but in the force of motion and sensation.

Nor can the animal be wholly protected by armor. Some portion of it must be exposed to danger. At least those flexible limbs which aid it in food-getting are in frequent peril, and need some form of protection. The loss of them can not well be made useful to the animal, as the loss of its exposed portions is to the plants.

Evidently the animal is capable of a much wider range of form-evolution than the plant. In its mobility of variation it has branched

out in many directions, but the possible height attainable by each general direction of growth is limited by certain principles, which we may be able to discover.

Both herbivorous and carnivorous animals may exist in fixed and in motile forms—food-attracting and food-seeking adaptations. The fixed forms are principally or entirely water-animals, comprising the Sponges, a large section of the Polyps, the lower forms of the Echinoderms, with some divergent forms, such as the Bryozoa, the Tunicata, and the Barnacles.

These are saved the necessity of moving, by the fact of their being tenants of a liquid whose moving currents bring them food, and by being capable of themselves producing water-currents, on which food is borne to them. Their necessary movements are reduced to the motion of tentacles—current-making or food-seizing organs. No sense is requisite except touch, and therefore no higher degree of sensibility is developed. These fixed forms thus necessarily remain at the foot of the ladder of progress, being but a step above the Protozoa, or single-celled animals. They may be classed, however, as superior to the internal parasites of animals, which live by imbibing elaborated animal juices, and need no motile nor sense organs.

But, as soon as an animal obtains powers of free motion, it comes at once into contact with a much wider range of conditions and needs to gain extended powers. It is, moreover, placed under seeming disadvantages, which are really of high efficacy in its development. It possesses no stone castle of refuge, from which it has but to extend its retractile arms. It is, therefore, exposed to much greater dangers, its whole body being open to the assault of foes.

There are two general methods by which protection from these perils is gained: the first by armor; the second by activity and sensory acuteness. The armored animals are necessarily heavier, less active, and less flexible, than the unarmored. The latter depend for safety on activity and variety of motion, on quickness of sense, and on weapons of defense. They are, consequently, more highly developed than the armored, whose firm coating forms their main protective adaptation.

They also come into contact with a much wider range of natural conditions, their more extensive excursions accustoming them to more varied forms of food, adapting them to wider surface and temperature relations, and exposing them to more numerous foes. Thus they must become fitted to a wider environment, and their powers be more specialized; the naked, flexible, active animal being thus necessarily the highest in point of development.

These general views lead us to their particular application to the existing animal types. We think it can be shown that each type has had full opportunities of unfoldment, and has reached the extreme limit of its line of growth.

There are certain requirements of the animal organism to which every adaptation must conform. Underlying the stomachic type is the more primary fact that the natural form of colloid matter is the globe. Like all fluid or semi-fluid matter it tends to curve about a general center of attraction, in distinction to the angular extension of the crystal. This tendency shows itself in all parts of all animal forms, and also in these forms as wholes, the globe being departed from only through functional necessity, or from the superposition of a series of organs, each with a globular tendency, yielding, through mutual pressure, a more or less ovoid result.

In the Protozoa we have the globular form, diversified by temporary, improvised limbs, or by permanent organs. In the Metazoa variation from the globe takes place in axial directions—the fixed animals having usually but two axes of departure from the sphere; the moving animals having ordinarily three axes—a longitudinal, a vertical, and a transverse. The general result is the production of the round, flattened form of the two-axed, and the oval form of the three-axed animals; the further departure being in the production of limbs—appendages devoted to motion, or to assault and defense.

If now we take the Gastrula, the simple stomach-sac, for the primitive form of the many-celled animal, and the earliest phase of derivation from the Protozoa, it is easy to perceive that this hollow animal globe may vary in three different modes.

First, it may retain its sac-like form and stomach-opening, developing tentacles about the mouth, and radiated body divisions; thus passing from the single axis of the Gastrula to the double axis of the polyp.

Secondly, it may flatten, until it resembles a sack with the open top pressed down upon the bottom, and the sides bulging outward into a circle. If, now, radiated arms extend outward from this rounded side, we have the starfish type of organism.

Thirdly—still preserving its affiliation to the globe—it may lengthen instead of flattening. From this mode of development would come the longitudinal type of animals, the vermes, or worm-forms.

A still more primitive departure from the original Gastrula form is found in the sponge, in which the body-wall is pierced by minute apertures, through which food-bearing currents are drawn into the general internal stomach, and forced out again through the mouth. The low organization of the sponge results from the fact that it does not even require the mouth-arms of the polyp as an aid in food-getting. Its only motive apparatus is the cilia, or vibrating hair, of the Infusoria.

Of the three forms which thus seem to be the first natural variations of the Gastrula—the globular, the flattened, and the lengthened—the first two naturally rest on one extremity of the longitudinal or stomach axis; the other, or mouth extremity, being directed upward. Thus only these two extremities are exposed to diverse conditions, the

one being in contact with the ground, the other with water or air. The intermediate surface is affected in but one manner. It being everywhere similarly influenced, its whole development is similar, and a radial or two-axed form results.

In the lengthened forms the longitudinal or intestinal axis naturally becomes horizontal. The two extremities of this axis develop into mouth and vent. But the intermediate portions are also differently conditioned. Vertically a lower face is in contact with the ground, an upper face with water or air. Thus ventral and dorsal surfaces are produced. Transversely, the opposite sides are similarly affected, and develop similarly. Gravitation also tends to produce a shortening of the vertical and a widening of the transverse axis. Thus the three-axed animal appears, a lengthened form, with mouth-opening at the anterior-moving extremity, with diverse dorsal and ventral surfaces, with similar lateral surfaces, and with a tendency to become flattened vertically.

In this lengthened, or worm type, appears an animal form more highly conditioned than any possible two-axed form, and capable of far higher development. It is much the best adapted for rapid movement, its long, narrow shape being well calculated to overcome the frictional resistance of water or air; while it is capable of a flexibility not possible to the compact types of animal form.

Consequently, from the primitive types of animal form we have so far considered, we find two general lines of development. The first of these is a tendency in the compact types to become lengthened in form, to lose their protective armor, and to assume the free-moving condition—their most advanced genera being thus constituted. On the other hand, a retrograding tendency shows itself in certain sections of the lengthened animal type, compact forms appearing. And, significantly, these envelop themselves in shelly or horny armor for protection, become sluggish in motion, and fail to develop the acute sensitiveness and other advanced powers of the naked worms.

Such being the primitive and secondary form-evolving tendencies, the production of organs of motion is in strict accordance therewith. In the radiated polyps the limbs appear as head-organs. These are so ill-adapted to the production of free motion, that the solitary Polyps have not developed into this condition, except in the case of the Medusæ or jelly-fish. And these in no instance seek to swim by aid of their arms, a slow movement being gained by umbrella-like contractions of their radiate body disk.

In the Echinoderm family—one of the reversions from the longitudinal type—the shortening of the intestinal axis has brought it into such close relations with the radiate type that the difference is only clearly distinguishable in its embryo stage of existence. Its intestinal axis has become vertical, and it has gained radiated limbs—not head, but side limbs. By the aid of these the free-moving Echinoderms

manage to progress slowly, but they depend more particularly on their armor for protection.

In the Mollusk family—another form of reversion from the primitive longitudinal or three-axed form—the conditions of existence necessitate other motive organs. This family of animals, instead of clothing itself in a dermal armor like the Echinoderms, produces a limy covering, a movable house to which it is not anatomically connected, and which principally differs from the stone mansion of the polyp in being movable. Within this house the mollusk preserves his three-axed form; having no such strong inducement to yield it as has the Echinoderm. But his contact with exterior nature is but a head and foot contact. He therefore develops head-limbs—tentacular organs—while his slow progress is gained by alternate expansions and contractions of a muscular portion of the ventral surface.

Thus the lower types of animal form are forced, by the necessities of their environment, to evolve certain general anatomical conditions, which, as we shall hereafter see, act as a fatal drag on their subsequent efforts to occupy the higher fields of life.

The worm type has, from the beginning, a marked advantage over them. The creeping forms of this type would naturally tend to develop moving organs at their points of contact with the ground, yielding ventral limbs, extended along the body. Breathing organs might appear on the dorsal surface, in contact with the water; or at the mouth, where inflowing currents would yield the fullest water contact.

In the swimming worms a somewhat different process of limb development would naturally arise. Here, for the freest degree of motion, some form of fin must replace the limb of the creeping worm. There is reason to believe that fins first arose as lateral extensions of the flattened body. This general fin—under the late theory of limb development—in time lost its continuity, and broke up into four separate sections, whence arose the four limbs of the future Vertebrates.

The possession of such longitudinal body-limbs or fins gives much greater rapidity of motion to the worm type than is possible to the head-limbed or radiate body-limbed types. As a consequence of their motive facility they remain naked, rapidity of motion and keenness of sense giving them powers of attack and escape not needed by the tentacled and armored forms.

In fact, the advantage of the longitudinal extension is so patent that we find all the lower types making efforts to attain it, and in this manner reaching their highest limit of progression. This constitutes the next step in the evolution of animal form, and one which presents some exceedingly curious phases.

The phases here referred to are not displayed by the mollusks or the Echinoderms. We shall therefore first speak of their simpler mode of attaining their highest development.

In the mollusk it is attained by a lengthening of the compact body,

while the shell becomes internal instead of external. It continues to be useful as a basis of muscular attachment, but no longer as a defensive armor.

The whole development of the mollusks, from the lowest bivalve to the highest univalve form, has tended to the production of head-limbs, and a compact, bag-like body. In their naked state their evolution is limited by this hereditary constitution. Two modes of motion are possessed, the swimming and the creeping. For use in the first there is a fin-like expansion of the body, which enables them tó move with much rapidity, while backward motion is gained by expulsion of water from between the arm-membranes. But the body continues rigid, and is at a disadvantage as compared with the flexible worm type.

Creeping motion is gained by a development of sucking-disks upon the arms, which serve for a slow dragging of the body, turned head downward, and also as an efficient agent in the capture of game.

This highest mollusk, the cuttle-fish, is utterly unfitted for a land residence despite its acute sense-organs. The ink-bag, which enables it to conceal itself in the water, would be of no use to it on land; its tail-fins or its radiated head-arms could not be changed into efficient organs of land-motion; it would, therefore, be at a great disadvantage as compared with the body-limbed, flexible-framed vertebrates. Thus the highest development of the mollusk type is unsuited by its defective constitution to a land residence, and can only progress to the limited extent permitted by the restrictions of a water residence.

In the Echinoderms a similar lengthening of the body is gained. Of the free forms, we have the flattened starfish, with the arms sometimes developed at the expense of the body, the body sometimes at the expense of the arms; the globular sea-urchin, with its ambulacral arms; and the lengthened Holothuroid. In this latter is displayed what seems almost an intelligent effort to imitate the worm type. Unlike the other Echinoderms, its intestinal axis becomes horizontal instead of vertical. Thus, like the worms, it attains dorsal and ventral surfaces, exposed to diverse conditions. As a consequence, of its five rows of ambulacral suckers, those on the dorsal surface disappear in the most advanced genera, only the three ventral rows being retained. The distinguishing radiate structure is displayed only by its circle of mouth-tentacles, the food-getting organs. It also loses the calcareous outer armor of the lower Echinoderms, replacing it by a flexible, leathery skin.

But, with these several advances toward the worm type, the hereditary disadvantages of the Holothuroid act as impassable restrictions to any great development. The organs of the higher senses are wanting. It is in no way adapted to swimming, its exterior organs being quite unfitted to develop into fins. Nor are the ambulacral suckers suited to any rapid progression. An utter change in character would be necessary to adapt them to a walking or running movement. Thus

this line of animal evolution has reached its ultimate at a much lower level than that attained by the Mollusca.

But, by this review of what we may, in a figurative sense, call Nature's failures in animal evolution, we begin to perceive the requisites to success. The retrograde forms, after again developing into the lengthened type, are constitutionally restricted from gaining certain structural advantages which are primitive possessions of other types.

These advantages we may classify as body-limbs, adapted to walking or swimming; and an articulated body, capable of a flexibility not possible to the compact, single-sectioned animals. All the other animal types, besides those we have considered, have made an effort to attain this articulated structure, sometimes by a very curious process. The success attained in this effort is closely dependent upon the primitive structure of the articulated animal, which has placed impassable restrictions in the path of some types.

In the polyps and in the articulates the end seems to have been attained by the linking together of a colony of animals, forming a structure, originally compound, which has become simple by a division of functions between the successive sections.

In the Vertebrata alone has it been attained by the articulation of an originally single animal. The vertebrates thus possess special structural advantages denied to the other articulated forms, the compound origin of these latter curiously limiting their powers of evolution.

In this merging of societies into single animals, Nature presents us instances of every step of the process, from those in which individuality remains intact, to those in which it is subordinated to the requirements of the compound animal.

A first step in the process is displayed by the Tunicate mollusks. The Salpa—one form of these shell-less creatures—is a free-moving animal, progressing by the aid of water, which is drawn into one end of its straight intestine and expelled at the other. They exist in two conditions, the single and the compound. In the latter they unite into long chains, not organically connected, but apparently adhering by little suckers.

This primitive combination seems assumed for one advantage only, that of aiding their motion. The animals in the chain contract and expand simultaneously, the whole chain moving like one lengthened animal.

The same end is achieved in a still more curious way in the Pyrosoma, another of the Tunicata. These little creatures so group themselves as to form a hollow tube, open at one end and closed at the other. The minute animals which compose the walls of this tube have one gill-opening extended outward, the other inward. Thus they draw water from outside and discharge it into the interior of the tube. This being closed at one end, the water is necessarily driven from the

other, giving to the odd, phosphorescent, living tubes a lengthwise movement through the ocean.

The Ascidians—a family of fixed Tunicates—present societies to some extent organically connected. They are grouped by a common connection of their mantles, or rise successively from a common stem, through which an organic unity is established. Yet their individuality continues; for, if one of the Ascidians has its circulation cut off, by a ligature, from the common stem, it continues to exist independently.

In the fixed polyps the subordination of character resembles that of the Ascidians. It is carried further, however. Thus, in some instances, not only is the common stem fed by the efforts of a series of individual mouths, but there seems to be a sensitive connection. If, for instance, one of the expanded animals of an Alcyonium community be touched, not only does this animal contract, but gradually the remaining animals of the community contract also.

Again, in the Hydrozoa, individual members of the community are specialized as reproductive organs, being fed through the common stem by the feeding individuals. In these cases the merging of individuality has extended much beyond the simple case of the Salpæ, certain members of a society being specialized as organs of a compound animal. These reproductive buds, however, in many cases regain their individuality in a very peculiar manner. They separate from the common stem, and continue to exist as free-swimming animals. But their specialized development has produced material modifications in their form and internal organization. They are no longer fixed polyps, but free Medusæ, retaining only a general resemblance to the polyp type, and swimming by means of contractions of their umbrella-like disk.

By this strange modification of the polyp form, to achieve special purposes, a new free animal form is produced, which sometimes follows its new line of development so as to yield an animal markedly distinct from its unspecialized brothers of the same community. Such is one of the many strange modes in which Nature has sought to produce new forms of animal life.

But the greatest subordination of individuality is shown in the Siphonophoræ, a family of Hydrozoa in which a distinct effort seems to be made to attain the elongated, free-swimming form, through combination. In some of these the evolution of a colony into a single animal is almost complete. A large number of individuals are connected by a common stem; but these individuals are so specialized in function as to be no longer capable of a separate existence. They have lost certain powers, and developed others, so that they are reduced to the condition of special organs of a single animal. Some act as food-catching organs, some as mouths, some as reproductive and nursing members, and, by a strange transformation, some have become bell-like organs, which, by successive contractions, expel the water, and force the whole community through the seas.

These swimming bells are not unlike the Medusæ in this particular, but have become far more specialized than the Medusæ, as they possess none of the organs requisite to individual life.

In the Physalia, or Portuguese man-of-war, the connecting body is developed into a floating bladder, moving by force of the winds, and with its variously modified polyps beneath it.

Such are some of the modes adopted by Nature to produce free motion in the lower types of animal life. The animals produced by this social subordination of function are imperfect because the subordination is indefinite. There is not a single organ adapted to each function, but a variable number. And the very means by which propulsion through the water is gained renders this imperfection necessary. For, if a single individual constituted each organ, the animal would become compact, and be moved by a single contracting bell. Its powers of motion would be reduced to those of the Medusæ, and its organization retrograde toward the original compact stage.

This line of progress, with its necessarily imperfect specialization, is evidently incapable of attaining the level of the Echinoderm, much less of the mollusk.

But another line—that of the segmented animals—seems much better adapted to attain a high grade of evolution. Not but that its segments possess anatomical characters as stubborn as those of the Radiates, but that these are less restrictive to a high evolution.

It is, of course, not the usual view to consider the Articulates as the result of an original social organization. The segments, in the higher genera, are so specialized that they now exist but as organic parts of a single animal. And yet, if we consider the lower articulated worms, evidences of such an origin may be discovered.

In these lowest Articulates scarcely any difference is to be traced between the segments. The anterior, from its position, acts as a mouth, but otherwise they are as similar as the individual Salpæ. But the most significant feature is that in many cases each of them possesses the organization of an individual. Each segment still retains its separate nervous ganglion, its separate muscles, its separate limbs, frequently its separate breathing organs, and, in a partial degree, its separate circulation. These are only subordinated to the extent of being joined by connecting links, while the intestine of each becomes continuous as a common intestine.

In fact, this organic individuality is carried, in certain cases, to a yet more significant extent. The organs of special sense—the most highly specialized of animal organs—are, in some instances, retained by the separate segments. There are not only existing worms with eyes at each extremity of the body, but others which possess eyes in each separate segment.

Thus we are led not alone to the conception of an original animal which became associated into the Articulates, but even to some idea

of the organization of this primitive animal. If we assign to it the organs still possessed by the segments of the Annelides, we find it to have had an intestine separate from the circulation, being thus superior to the polyps. It had also simple nervous and muscular systems, and immature eyes, a chitinous armor, a water-vascular system, and possibly distinct exterior breathing organs and feet. It may, indeed, have been the primitive form from which other animal types besides the Articulates originated—through a diverse process of evolution.

It is not improbable that the Articulate condition was reached, not by a combination of free individuals, but by a continued adherence of longitudinal buds. The increase in number of segments by division is still common in Articulates. The minute fresh-water worm called the Nais, is separated into two sections by a bud which appears in the center of the body. One section develops a head and the other a tail, at the ends adjoining the bud. But the bud itself again and again divides, each division becoming a young Nais, so that finally a chain of worms is formed, all organically connected, and fed by the mouth of the anterior Nais. Eventually they separate, each becoming a free individual.

The question now arises as to how a developing force would act on such an articulated society. The highest results of evolution are reached through concentration of function. Such specialization is opposed to a continuous increase in the number of segments, and must tend to the production of a definite organism, of limited extent. The activity of this organism is increased by its gaining limbs more useful than the bristle-like setæ of the Annelides. Its range of food expands when its fore-limbs are changed into food-getting organs. Its powers of motion increase when the body is compacted, and the number of joints decreased, by a welding of several segments into one.

But whence come such new limbs? A consideration of their character leads us to the idea that they may proceed from a simple continuance of the budding process, acting, in this case, in a lateral direction instead of lengthwise. For the limbs are hollow, jointed segments, covered with chitine like the body-segments. They seem, indeed, to be specialized side-segments which have lost their internal organs through disuse, retaining only their chitinous armor, their muscles, and their intestinal cavity. And the successive joints of the limbs appear to be formed by a continuance of the budding process. One evidence of this is the fact that they may be reproduced by budding when broken off at the joint; and also that lateral budding again takes place at the extremity of the limbs, yielding double tarsi or pincers in the head-limbs.

Such is the character of the articulated animal; and it appears as if this persistent partial individuality of the segments must prevent that complete localization of function which seems necessary to the greatest animal development.

As we ascend to the higher members of the Articulate type, the specialization of function increases, but not sufficiently to obliterate all the individuality of the segments. The tendency in the Arthropods is toward a continuous welding of the segments. Thus, in the Crustaceans we find twenty or twenty-one segments compacted into three body sections. In the higher families these three are reduced to two; and, in the highest crabs, the abdominal section becomes so reduced that all the body functions are performed by a single section.

At the same time the chitinous armor of the segments becomes a continuous cortical armor; and the chain of nerve-ganglia is reduced to a single large ganglion, which supplies nerve-fibers to all the body.

In this manner the Crustacean reaches its most specialized condition, but only by a loss of its longitudinal extension, and a return to the compact, slow-moving, armored type of animal. Thus, its highest evolution has produced an organization antagonistic to any advanced degree of development.

Of the air-breathing Arthropods the Arachnidæ seem to be closely allied to the Crustaceans. They have the same compactness of organization; are not, as a rule, adapted to swift motion; and are inferior to the high Crustaceans from the fact that their tendency is toward development of the abdomen, instead of the head section, as in the crabs.

The insects and Myriapods do not possess the relations to the Crustaceans shown by the spiders and their allies. On the contrary, their larval form seems to indicate a separate line of descent from the worms. Different as insects and Myriapods are in their mature forms, they appear to have had a common origin—the embryo of the Myriapods passing through a stage that resembles the larval stage of insects. They seem, indeed, to have developed from their primitive form in opposite directions, the segments being multiplied in the Myriapods and reduced in the insects. The embryo of the Myriapod has at first but three pairs of legs. At a later period posterior legs bud successively from the new-formed segments. There seems to be no fixed limit to the number of segments, since they continue to increase throughout life. And their individuality is strongly declared, each segment possessing the organs necessary to a separate life, as a nerve-ganglion and fibers, breathing organs, muscles, an intestine, and a vascular space. These organs, if redeveloped from their partly aborted condition, might well suffice to sustain life in separate animals.

Even in the highest of the Arthropods—the insects—this hereditary individual organization of the segments continues manifest; these organically independent members of the society stubbornly resist the cession of their primitive functions, only partly yielding to the common needs, and thus retaining a generalization of function which is repressive of any high development.

The animal best suited for progression is one which has all its

functions separately concentrated. Its aëration, its circulation, its sensation must have single, localized centers, and its limbs be reduced to the smallest possible number, and separated in duty. These requisites are only fully attained in the human form. They are constitutionally prohibited to the segmented animals.

In the insects the persistent individuality of the segments is shown partly in their six legs, each pair attached to a segment; but more particularly in their generalized nervous and respiratory systems. To a great extent each segment preserves its nerve-ganglion. So, to a similar extent, each segment does its own breathing, the whole body becoming one generalized lung. The blood circulation, which is only partly confined to specialized blood-vessels, is accompanied by a general air circulation. There is nothing resembling the localized relations of these circulating systems as seen in the Vertebrates.

Such are the constitutional limitations to development in the Articulates, probably resulting from their social origin. The effort to overcome these limitations in the crabs has resulted in organic conditions opposed to a high development. How is it in the insects? In them the segments are so welded as to form three distinct body sections. In the higher insects the individuality of the segments is so reduced that the nerve-ganglia of the thoracic segments are concentrated into one ganglion, while a single head-ganglion, of large size, officiates as a brain. Their muscular force is greater in proportion than that of Vertebrates, so that they are strong, active, and enduring in bodily vigor. What natural influence is it that has restricted their development?

This may not be difficult to discover. We have seen that the too great compacting of the articulated body, as in the crabs and spiders, has proved a hindrance to development. The three sections of the insect body, each devoted to a single class of duties, has given them variety of motion, and more diversified food-getting functions. But it has otherwise worked injuriously. Rapid variations in movement require that these sections should be united by flexible joints. But these joints are articulations of an external skeleton, and can only be produced by a deep depression of this cortical armor into the regions dividing the sections. Thus the continuity of the body is almost broken at these joints. A similar relation exists between the joints of the limbs.

It seems evident from these considerations that the insect is not constituted to attain a large size. Conditions which are suitable to a small body might prove utterly unfitted to the requirements of a larger organism. Let us imagine an insect of the size of an ox; walking on its six many-jointed, hollow legs; its body composed of three almost separate sections; breathing through air-holes in its sides, its whole body but an air-tank, or lung. Even if such a growth were possible, it would obviously be at a disadvantage as compared with the Verte-

brates. Whatever size it might have attained in the absence of the Vertebrata, it certainly would be unfitted to compete with these better adapted animals for the possession of the higher fields of life.

Insects thus seem restricted to a small form, contracted localities, and a narrow range of conditions. The ants, their highest form, is one of the most limited in range. It is highest in having best succeeded in adapting nature to its needs, and, in so doing, having developed a superior mentality; but it can not advance beyond the needs of its contracted environment.

In the various animal types we have considered, Nature seems to have exhausted all side-issues in her efforts to produce an animal form adapted to a high grade of evolution. The persistent individuality of the segments hinders a colony from merging into an individual capable of an advanced phase of development.

Another and simpler method remains to be considered; the direct elongation of a single individual—not the elongation of a previously organized animal, but a primary derivative, unshackled by anatomical difficulties.

For high progress in this individual, certain conditions are necessary. It must not seek safety in a coat of armor. It must save itself from danger by powers of flight and acuteness of sense. In a water residence the most effective flight is gained by swimming. Therefore our worm must become a swimming animal, its sides being flattened into swimming-flaps.

In such an individual the functions would be specialized, as they were in the individuals which became welded into the Articulate. Indeed, the Vertebrate and the Articulate may have had a single origin in this primitive organic form.

The swimming worm we are considering has no hindrances to specialization of function. His side-flaps may be reduced to local fins. His intestinal tube—not acting as a series of sectional stomachs—may become localized in function, its anterior portion acting as a lung, its posterior portion as a stomach. There are several advantages in this. The circulation is no longer exposed to danger by a perilous thinning of the outer surface into branchiæ. The food being drawn in by water-currents, oxygen is extracted from the water by the anterior intestine, and aliment by the posterior. Similarly, the nerve and muscle systems are single and specialized, and the sense organs local.

But another condition is necessary to the full adaptation of this swimming animal to its situation. Its swift motion necessitates muscular vigor, and requires some firm point of attachment for the muscles. In all the armored types the shell, or outer coating, serves for this purpose. In the naked worm there is no such exterior point of attachment, and an interior one must be developed.

Thus we have arrived at the necessity of an interior skeleton, an

organic condition not displayed in all the vast field of life we have so far reviewed, except imperfectly, in the Cephalopod mollusks.

This is, at first, attained by the indurating of a dorsal layer of flesh into a cartilaginous cord, which stiffens the body while leaving it flexible, and furnishes points for muscular attachment.

Only a few instances remain of this earlier condition of the Vertebrate type. All others have disappeared. In the embryo of a Tunicate animal, the Ascidia, both the cartilaginous cord and the intestinal branchiæ appear. In its mature form it becomes a fixed animal, and loses this cord. But in the Appendicularia, a related animal, the cord is retained throughout life. It is also retained, in a more complete development, in the Lancelet Amphioxus, a creature having strong vertebrate affinities in its extended nerve-cord and its general functional system.

But one further step is required to produce the typical Vertebrate from such an original. This is the formation of joints in the cartilaginous cord, when it has become so firm as to resist the lateral movements of the body, or is hardened by deposition of carbonate of lime.

There is nothing in this like the welding of segments in the Articulate. The vertebrate joints display none of the separate vital animal functions. They yield every indication of being produced in the mode indicated, by the stress of an undulating body. The joints in the subsequent limbs resemble them in character, and seem to be formed in the same manner. The Lancelet is not jointed; it is a single individual. But the worm from which the Articulate arises *is* jointed, and each joint is possessed of all the vital functions.

Thus it appears that the Vertebrate animal starts in the race of life with advantages possessed by none of its competitors. It remains to trace the steps of its development.

THE PROFUSION OF LIFE.*

By ARABELLA B. BUCKLEY.

I WONDER whether it ever occurs to most people to consider how brimful our world is of life, and what a different place it would be if no living thing had ever been upon it? From the time we are born till we die, there is scarcely a waking moment of our lives in which our eyes do not rest either upon some living thing or upon things which have once been alive. Even in our rooms, the wood of our furniture and our doors could never have been if life did not exist; the paper on our walls, the carpet on our floors, the clothes on our back, the cloth upon the table, are all made of materials which life has

* From the Introduction to "Life and her Children," in press by D. Appleton & Co.

produced for us; nay, the very marble of our mantel-piece is the work of once living animals, and is composed of their broken shells. The air we breathe is full of invisible germs of life; nor need we leave the town and go to the country in search of other living beings than man. There is scarcely a street or alley where, if it be neglected for a time, some blade of grass or struggling weed does not make its appearance, pushing its way through chinks in the pavement or the mortar in the wall; no spot from which we can not see some insect creeping, or flying, or spinning its web, so long as the hand of man does not destroy it.

And when we go into the quiet country, leaving man and his works behind, how actively we find life employed! Covering every inch of the ground with tiny plants, rearing tall trees in the forest, filling the stagnant pools full of eager, restless beings; anywhere, everywhere, life is at work. Look at the little water-beetles skimming on the surface of the shady wayside pool, watch the water-snails feeding on the muddy bank, notice the newts putting their heads above water to take breath, and then remember that besides these and innumerable other water animals visible to the naked eye, the fairy-shrimp and the water-flea, and other minute animals, are probably darting through the water, or floating lazily near its surface, while the very scum which is blown in ridges toward one corner of the pool is made up of microscopic animals and plants.

Then, as we pass over plain, and valley, and mountain, we find things creeping innumerable, both great and small, hidden in the moss or the thick grass, rolled up in the leaves, boring into the stems and trunks of trees, eating their way underground or into even the strongest rock. The lion, the tiger, and the elephant, roaming over Asia, Africa, and India, rule a world of their own where man counts for very little. Even in our own thickly peopled country hares and rabbits multiply by thousands in their burrows, and come to frolic in the dusk of evening when all is still. The field-mice, land and water rats, squirrels, weasels, and badgers, have their houses above and below ground, while insects are to be found everywhere, testifying to the abundance of life. Not content, moreover, with filling the water and covering the land, this same silent power peoples the atmosphere, where tiny bats, butterflies, bees, and winged insects of all forms and shapes and colors, fight their way through the ocean of air, while birds, large and small, sail among its invisible waves.

And by and by we reach the sea, and there we find masses of tangled seaweed, the plants of the salt water, while all along the shores myriads of living creatures are left by the receding tide. In the rocky pools we find active life busily at work. Thousands of tiny acorn-shells, scarcely larger than the head of a good-sized pin, cover the rocks and fling out their thread-like arms in search of food. Small crabs scramble along, or swim across the pools, sand-skippers dart through the water, feeding on the delicate green seaweed, which in its

turn is covered with minute shells not visible to the naked eye, and yet each containing a living being.

Anywhere, everywhere, creatures are to be found, and even if we sail away over the deep silent ocean and seek what is in its depths, there again we find abundance of life, from the large fish and other monsters which glide noiselessly along, lords of the ocean, down to the jelly-masses floating on the surface, and the banks of rocky coral built by drops of living slime in the midst of the dashing waves. There is no spot on the surface of the earth, in the depths of the ocean, or in the lower currents of the air, which is not filled with life whenever and wherever there is room. The one great law which all living beings obey is to "increase, multiply, and replenish the earth"; there has been no halting in this work from the day when first into our planet from the bosom of the great Creator was breathed the breath of life, the invisible mother ever taking shape in her children.

No matter whether there is room for more living forms or not, still they are launched into the world. The little seed, which will be stifled by other plants before it can put forth its leaves, nevertheless thrusts its tiny root into the ground and tries to send a feeble shoot upward. Thousands and millions of insects are born into the world every moment which can never live, because there is not food enough for all. If there were only one single plant in the whole world to-day, and it produced fifty seeds in a year, and could multiply unchecked, its descendants would cover the whole globe in nine years.* But, since other plants prevent it from spreading, thousands and thousands of its seeds and young plants must be formed only to perish. In the same way one pair of birds having four young ones each year, would, if all their children and descendants lived and multiplied, produce *two thousand million* in fifteen years,† but, since there is not room for them, all but a very few must die.

What can be the use of this terrible overcrowding in our little world? Why does this irresistible living breath go on so madly, urging one little being after another into existence? Would it not be better if only enough were born to have plenty of room and to live comfortably?

Wait a while before you decide, and think what every creature needs to keep it alive. Plants, it is true, can live on water and air, but animals can not; and, if there were not myriads of plants to spare in the world, there would not be enough for food. Then consider again how many animals live upon each other. If worms, snails, and insects were not over-abundant, how would the birds live? Upon what would lions and tigers and wolves feed if other animals were not plentiful, while, on the other hand, if a great number of larger animals did not die and decay, what would the flesh-feeding snails and maggots and other insects find to eat? And so we see that for this reason alone

* Huxley. † Wallace.

there is some excuse for the over-abundance of creatures which life thrusts into the world.

But there is something deeper than this to consider. If in a large school every boy had a prize at the end of the half year, whether he had worked or not, do you think all the boys would work as hard as they do or learn as well? If every man had all he required and could live comfortably, and bring up his children to enjoy life without working for it, do you think people would take such trouble to learn trades and professions, and to improve themselves so as to be more able than others? Would they work hard day and night to make new inventions, or discover new lands, and found fresh colonies, or be in any way so useful or learn so much as they do now?

No, it is the struggle for life and the necessity for work which make people invent and plan, and improve themselves and things around them. And so it is also with plants and animals: life has to educate all her children, and she does it by giving the prize of success, of health, and strength, and enjoyment to those who can best fight the battle of existence, and do their work best in the world.

Every plant and every animal which is born upon the earth has to get its own food and earn its own livelihood, and to protect itself from the attacks of others. Would the spider toil so industriously to spin her web if food came to her without any exertion on her part? Would the caddis-worm have learned to build a tube of sand and shells to protect its soft body, or the oyster to take lime from the sea-water to form a strong shell for its home, if they had no enemies to struggle against and needed no protection? Would the bird have learned to build her nest or the beaver his house if there were no need for their industry?

But as it is, since the whole world is teeming with life, and countless numbers of seeds and eggs and young beginnings of creatures are only waiting for the chance to fill any vacant nook or corner, every living thing must learn to do its best and to find the place where it is most useful, and least likely to be destroyed by others. And so it comes to pass that the whole planet is used to the best advantage, and life teaches her children to get all the good out of it that they can.

If the ocean and the rivers be full, then some must learn to live on the land, and so we have, for example, water-snails and land-snails, and whereas the one kind can only breathe by gills in the water, the other breathes by means of lungs in the air, while between these are some, such as the river-snails of the tropics, which have both gills and lungs, and can breathe in both water and air. We have large whales sailing as monarchs of the oceans, and walruses and seals fishing in its depths for their food, while all other animals of their kind live on the land.

Then, again, while many creatures love the bright light, others take advantage of the dark corners where room is left for them to live. You can not lift a stone by the seaside but what you will find some living thing under it, nor turn up a spadeful of earth without disturb-

ing some little creature which is content to find its home and its food in the dark ground. Nay, many animals for whom there is no chance of life on the earth, in the water, or in the air, find a refuge in the bodies of other animals and feed on them.

But in order that all these creatures may live, each in its different way, they must have their own particular tools to work with, and weapons with which to defend themselves. Now, all the tools and weapons of an animal grow upon its body. It works and fights with its teeth, its claws, its tail, its sting, or its feelers; or it constructs cunning traps by means of material which it sucks out of the water, as in the case of the oyster, or gives out from its own body, like the spider. It hides from its enemies by having a shape or color like the rocks or the leaves, the grass or the water, in which it lives. It provides for its young ones either by getting food for them, or by putting them, even before they come out of the egg, into places where their food is ready for them as soon as they are born.

So that the whole life of an animal depends upon the way in which its body is made; and it will lead quite a different existence according to the different tools with which life provides it, and the instincts which a long education has been teaching to its ancestors for ages past. It will have its own peculiar struggles and difficulties and successes and enjoyments, according to the kind of bodily powers which it possesses, and the study of these helps us to understand its manner of existence.

And now, since we live in the world with all these numerous companions, which lead, many of them, such curious lives, trying, like ourselves, to make the best of their short time here, is it not worth while to learn something about them? May we not gain some useful hints by watching their contrivances, sympathizing with their difficulties, and studying their history? And, above all, shall we not have something more to love and to care for when we have made acquaintance with some of life's other children besides ourselves?

The one great difficulty, however, in our way, is how to make acquaintance with such a vast multitude. Most of us have read anecdotes about one animal or another, but this does not give us any clew to the history of the whole animal world; and, without some such clew, the few observations we can make for ourselves are very unsatisfactory. On the other hand, most people will confess that books on zoölogy, where accounts are given of the structure of different classes of animals, though very necessary, are rather dull, and do not seem to help us much toward understanding and loving these our fellow creatures.

What we most want to learn is something of the *lives* of the different classes of animals, so that when we see some creature running away from us in the woods, or swimming in a pond, or darting through the air, or creeping on the ground, we may have an idea what its ob-

ject is in life—how it is enjoying itself, what food it is seeking, or from what enemy it is flying.

And, fortunately for us, there are an order and arrangement in this immense multitude, and in the same way as we can read and understand the history of different nations which form the great human family spread over the earth, and enter into their feelings and their struggles, though we can not know all the people themselves; so, with a little trouble, we may learn to picture to ourselves the general life and habits of the different branches of the still greater family of life, so as to be ready, by and by, to make personal acquaintance with any particular creature if he comes in our way.

CRITICISMS CORRECTED.

By HERBERT SPENCER.

II. T. E. CLIFFE LESLIE.

AN objection made to the formula of evolution by a sympathetic critic, Mr. T. E. Cliffe Leslie, calls for notice. It is urged in a spirit widely different from that displayed by Mr. Kirkman and his applauder, Professor Tait; and it has an apparent justification. Indeed, many readers, who before accepted the formula of evolution in full, will, after reading Mr. Cliffe Leslie's comments, agree with him in thinking that it is to be taken with the qualifications he points out. We shall find, however, that a clearer apprehension of the meanings of the words used and a clearer apprehension of the formula in its totality exclude the criticisms Mr. Leslie makes.

In the first place he dissociates from one another those traits of evolution which I have associated, and which I have alleged to be true only when associated. He quotes me as saying that a change from the homogeneous to the heterogeneous characterizes all evolution; and he puts this at the outset of his criticism as though I made this change the primary characteristic. But if he will refer to "First Principles," Part II, Chapter XIV (in the second and subsequent editions), he will find it shown that under its *primary* aspect evolution "is a change from a less coherent form to a more coherent form, consequent on the dissipation of motion and integration of matter." The next chapter contains proofs that the change from homogeneity to heterogeneity is a *secondary* change, which, when conditions allow, accompanies the change from the incoherent to the coherent. At the beginning of the chapter after that come the sentences—"But now, does this generalization express the whole truth? Does it include everything essentially characterizing evolution and exclude everything else? . . . A

critical examination of the facts will show that it does neither." And the chapter then goes on to show that the change is from an *indefinite* incoherent homogeneity to a *definite* coherent heterogeneity. Further qualifications contained in a succeeding chapter bring the formula to this final form: "Evolution is an integration of matter and concomitant dissipation of motion; during which the matter passes from an indefinite, incoherent homogeneity to a definite, coherent heterogeneity; and during which the retained motion undergoes a parallel transformation."

Now, if these various traits of the process of evolution are kept simultaneously in view, it will be seen that most of Mr. Cliffe Leslie's objections fail to apply. He says: "The movement of language, law, and political and civil union, is for the most part in an opposite direction. In a savage country like Africa, speech is in a perpetual flux, and new dialects spring up with every swarm from the parent hive. In the civilized world the unification of language is rapidly proceeding." Here two different ideas are involved—the evolution of a language considered singly, and the evolution of languages considered as an aggregate. Nothing which he says implies that any one language becomes, during its evolution, less heterogeneous. The disappearance of dialects is not a progress toward the homogeneity of a language, but is the final triumph of one variety of a language over the other varieties, and the extinction of them: the conquering variety meanwhile becoming within itself more heterogeneous. This, too, is the process which Mr. Leslie refers to as likely to end in an extinction of the Celtic languages. Advance toward homogeneity would be shown if the various languages in Europe, having been previously unlike, were, while still existing, to become gradually more like. But the supplanting of one by another, or of some by others, no more implies any tendency of languages to become alike than does the supplanting of species, genera, orders, and classes of animals, one by another, during the evolution of life, imply the tendency of organisms to assimilate in their natures. Even if the most heterogeneous creature, man, should overrun the earth and extirpate the greater part of its other inhabitants, it would not imply any tendency toward homogeneity in the proper sense. It would remain true that organisms tend perpetually toward heterogeneity, individually and as an assemblage. Of course, if all kinds but one were destroyed, they could no longer display this tendency. Display of it would be limited to the remaining kind, which would continue, as now, to show it in the formation of local varieties, becoming gradually more divergent; and the like is true of languages.

In the next case Mr. Leslie identifies progressing unification with advance toward homogeneity. His words are: "Already Europe has nearly consolidated itself into a heptarchy, the number of states into which England itself was once divided; and the result of the American

war exemplifies the prevalence of the forces tending to homogeneity over those tending to heterogeneity." To this the reply is that these cases exemplify, rather, the prevalence of the forces which change the incoherent into the coherent—which effect integration; that is, they exemplify evolution under its primary aspect. In the "Principles of Sociology," Part II, Chapter III, Mr. Leslie will find numerous kindred cases brought in illustration of this law of evolution. To which add that such integrations bring after them greater heterogeneity, not greater homogeneity. The divisions of the heptarchy were societies substantially like one another in their structures and activities; but the parts of the nation which correspond to them have been differentiated into parts carrying on varieties of occupations with entailed unlikenesses of structures—here purely agricultural, there manufacturing; here predominantly given to coal-mining and iron-smelting, there to weaving; here distinguished by scattered villages, there by clusters of large towns.

Again, it is alleged that an increasing homogeneity is shown in fashion. "Once every rank, profession, and district had a distinctive garb; now all such distinctions, save with the priest and the soldier, have almost disappeared among men." But while for a reason, to be presently pointed out, there has occurred a change which has abolished one order of differences, differences of another order, far more multitudinous, have arisen. Nothing is more striking than the extreme heterogeneity of dress at the present day. As Mr. Leslie alleges, the dresses of those forming each class were once all alike; now no two dresses are alike. Within the vague limits of the current fashion, the degree of variety in women's costumes is infinite; and even men's costumes, though having average resemblances, diverge from one another in colors, materials, and detailed forms in innumerable ways.

Other instances given by Mr. Leslie concern the organizations for carrying on production and distribution. He argues that "in the industrial world a generation ago a constant movement toward a differentiation of employments and functions appeared; now some marked tendencies to their amalgamation have begun to disclose themselves. Joint-stock companies have almost effaced all real division of labor in the wide region of trade within their operation." Here, as before, Mr. Leslie represents amalgamation as equivalent to increase of homogeneity; whereas amalgamation is but another name for integration, which is the primary process in evolution, and which may, and does, go along with increasing heterogeneity in the amalgamated things. It can not be said that a joint-stock banking company, with its proprietory and directors in addition to its officers, contains fewer unlike parts than does a private banking establishment: the contrary must be said. A railway company has far more numerous functionaries with different duties than had the one, or the many coaching establishments it replaced. And then, apart from the fact that the larger aggregate of

coöperators who, as a company, carry on, say, a process of manufacture, is more complex as well as more extensive, there is the fact, here chiefly to be noted, that the entire assemblage of industrial structures is, by the addition of these new structures, made more heterogeneous than before. Had all the smaller manufacturing establishments carried on by individuals or firms been destroyed, the contrary might have been alleged; but, as it is, we see that in addition to all the old forms there have come these new forms, making the totality of them more multiform than before. Mr. Leslie further illustrates his interpretation by saying: "Many of the things for sale in a village huckster's shop were formerly the subjects of distinct branches of business in a large town; now the wares in which scores of different retailers dealt are all to be had in great establishments in New York, Paris, and London, which sometimes buy direct from the producers, thus also eliminating the wholesale dealer." Replies akin to the preceding ones are readily made. The first is that wholesale dealers have not been at present eliminated; and can not be so long as the ordinary shopkeepers survive, as they will certainly do. In the smaller places, forming the great majority of places, these vast establishments can not exist; and in them, shopkeepers carrying on business as at present, will continue to necessitate wholesale dealers. Even in large places the same thing will hold. It is only people of a certain class, able to pay ready money and willing to go great distances to purchase, who frequent these large establishments. Those who live from hand to mouth, and those who prefer to buy at adjacent places, will maintain a certain proportion of shops, and the wholesale distributing organization needed for them. Again, we have to note that one of these great stores, such as Whiteley's or Shoolbred's, does not within itself display any advance toward homogeneity or despecialization; for it is made up of many separate departments, with their separate heads, carrying on business substantially separate—all superintended by one owner. It is nothing but an aggregate of shops under one roof instead of under the many roofs covering the side of a street; and exhibits just as much heterogeneity as the shops do when arranged in line instead of massed together. That which it really illustrates is a new form of integration, which is the primary evolutionary process. And then, lastly, comes the fact that the distributing organization of the country, considered as a whole, is by the addition of these establishments made more heterogeneous than before. All the old types of trading concerns continue to exist; and here are new types added, making the entire assemblage of them more varied.

From these objections made by Mr. Leslie, which I have endeavored to show result from misapprehensions, I pass to two others which are to be met by taking account of certain complicating facts liable to be overlooked. Mr. Leslie remarks that "in the early stages of social progress, again, a differentiation takes place, as Mr. Spencer has ob-

served, between political and industrial functions, which fall to distinct classes: now a man is a merchant in the morning and a legislator at night; in mercantile business one year, and the next, perhaps, head of the navy, like Mr. Goschen or Mr. W. H. Smith." Nothing contained in this volume explains the seeming anomaly here exemplified; but any one who turns to a chapter in the second part of the "Principles of Sociology," entitled "Social Types and Metamorphoses," will there find a clew to the explanation of it, and will see that it is a phenomenon consequent on the progressing dissolution of one type and evolution of another. The doctrine of evolution, currently regarded as referring only to the development of species, is erroneously supposed to imply some intrinsic proclivity in every species toward a higher form; and, similarly, a majority of readers make the erroneous assumption that the transformation which constitutes evolution, in its wider sense, implies an intrinsic tendency to go through those changes which the formula of evolution expresses. But all who have fully grasped the argument of this work will see that the process of evolution is not necessary, but depends on conditions; and that the prevalence of it in the universe around is consequent on the prevalence of these conditions: the frequent occurrence of dissolution showing us that, where the conditions are not maintained, the reverse process is quite as readily gone through. Bearing in mind this truth, we shall be prepared to find that the progress of a social organism toward more heterogeneous and more definite structures of a certain type continues only as long as the actions which produce these effects continue in play. We shall expect that, if these actions cease, the progressing transformation will cease. We shall infer that the particular structures which have been formed by the activities carried on will not grow more heterogeneous and more definite; and that if other orders of activities, implying other sets of forces, commence, answering structures of another kind will begin to make their appearance, to grow more heterogeneous and definite, and to replace the first. And it will be manifest that while the transition is going on—while the first structures are dissolving and the second evolving—there must be a mixture of structures causing apparent confusion of traits. Just as during the metamorphoses of an animal which, having during its earlier existence led one kind of life, has to develop structures fitting it for another kind of life, there must occur a blurring of the old organization while the new organization is becoming distinct, leading to transitory anomalies of structure, so, during the metamorphoses undergone by a society in which the militant activities and structures are dwindling while the industrial are growing, the old and new arrangements must be mingled in a perplexing way. On reading the chapter in the "Principles of Sociology" which I have named, Mr. Leslie will see that the above facts referred to by him are interpretable as consequent on the transition from that type of regulative organization proper to militant life to that type of regulative organization

proper to industrial life; and that, so long as these two modes of life, utterly alien in their natures, have to be jointly carried on, there will continue this jumbling of the regulative systems they respectively require.

The second of the objections above noted, as needing to be otherwise dealt with than by further explanation of the formula of evolution, concerns the increase of likeness among developing systems of civil law; in proof of which increase of likeness Mr. Leslie quotes Sir Henry Maine to the effect that "all laws, however dissimilar in their infancy, tend to resemble each other in their maturity": the implication to which Mr. Leslie draws attention being, that in respect of their laws societies become not more heterogeneous but more homogeneous. Now, though in their details systems of law will, I think, be found to acquire, as they evolve, an increasing number of differences from one another, yet in their cardinal traits it is probably true that they usually approximate. How far this militates against the formula of evolution we shall best see by first considering the analogy furnished by animal organisms. Low down in the animal kingdom there are simple mollusks with but rudimentary nervous systems—a ganglion or two and a few fibers. Diverging from this low type we have the great sub-kingdom constituted by the higher mollusca and the still greater sub-kingdom constituted by the vertebrata. As these two types evolve, their nervous systems develop; and though in the highest members of the two they remain otherwise unlike, yet they approximate in so far that each acquires great nervous centers: the large cephalopods have clustered ganglia which simulate brains. Compare, again, the mollusca and the articulata in respect of their vascular systems. Fundamentally unlike as these are originally, and remaining unlike as they do throughout many successive stages of ascent in these two sub-kingdoms, they nevertheless are made similar in the highest forms of both by each having a central propelling organ—a heart. Now, in these and in some cases which the external organs furnish, such as the remarkable resemblance evolution has produced between the eyes of the highest mollusca and those of the vertebrata, it may be said that there is implied a change toward homogeneity. No zoologist, however, would admit that these facts really conflict with the general law of organic evolution. As already explained, the tendency to progress from homogeneity to heterogeneity is not intrinsic but extrinsic. Structures become unlike in consequence of unlike exposures to incident forces. This is so with organisms as wholes, which, as they multiply and spread, are ever falling into new sets of conditions; and it is so with the parts of each organism. These pass from primitive likeness into unlikeness as fast as the mode of life places them in different relations to actions—primarily external and secondarily internal; and with each successive change in mode of life new unlikenesses are superposed. One of the implications is that, if in organisms otherwise different there arise like sets of conditions to which certain parts

are subject, such parts will tend toward likeness; and this is what happens with their nervous and vascular systems. Duly to coördinate the actions of all parts of an active organism, there requires a controlling apparatus; and the conditions to be fulfilled for perfect coördination are conditions common to all active organisms. Hence, in proportion as fulfillment approaches completeness in the highest organisms, however otherwise unlike their types are, this apparatus acquires in all of them certain common characters—especially extreme centralization. Similarly with the apparatus for distributing nutriment. The relatively high activity accompanying superior organization implies great waste; great waste implies active circulation of blood; active circulation of blood implies efficient propulsion; so that a heart becomes a common need for highly evolved creatures, however otherwise unlike their structures may be. Thus is it, too, with societies. As they evolve, there arise certain conditions to be fulfilled for the maintenance of social life; and, in proportion as the social life becomes high, these conditions need to be more effectually fulfilled. A legal code expresses one set of these conditions. It formulates certain regulative principles to which the conduct of citizens must conform that social activities may be harmoniously carried on. And, these regulative principles being in essentials the same everywhere, it results that systems of law acquire certain general similarities as the most developed social life is approached.

These special replies to Mr. Leslie's objections are, however, but introductory to the general reply; which would be, I think, adequate even in their absence. Mr. Leslie's method is that of taking detached groups of social phenomena, as those of language, of fashion, of trade, and arguing (though, as I have sought to show, not effectually) that their later transformations do not harmonize with the alleged general law of evolution. But the real question is, not whether we find advance to a more definite coherent heterogeneity in these taken separately, but whether we find this advance in the structures and actions of the entire society. Even were it true that the law does not hold in certain orders of social processes and products, it would not follow that it does not hold of social processes and products in their totality. The law is a law of the transformation of aggregates; and must be tested by the entire assemblages of phenomena which the aggregates present. Omitting societies in states of decay and dissolution, which exhibit the converse change, and contemplating only societies which are growing, Mr. Leslie will, I think, scarcely allege of any one of them that its structures and functions do not, taken altogether, exhibit increasing heterogeneity. And, if, instead of taking each society as an aggregate, he takes the entire aggregate of societies which the earth supports, from primitive hordes up to highly civilized nations, he will scarcely deny that this entire aggregate has been becoming more various in the forms of societies it includes, and is still becoming more various.

HYPNOTISM.*

By G. J. ROMANES.

CONSIDERING the length of time that so-called "animal magnetism," "mesmerism," or "electro-biology," has been before the world, it is a matter of surprise that so inviting a field of physiological inquiry should have been so long allowed to lie fallow. A few scientific men in France and Germany have indeed, from time to time, made a few observations on what Preyer has called the "Kataplectic state" as artificially induced in human beings and sundry species of animals; but anything resembling a systematic investigation of the remarkable facts of mesmerism has not hitherto been attempted by any physiologist in our generation. The scientific world will therefore give a more than usually hearty welcome to a treatise which has just been published upon the subject by a man so eminent as Heidenhain. The research of which this treatise is the outcome is in every way worthy of its distinguished author; for it serves not only to present a considerable and systematic body of carefully observed facts, but also to lead the way for an indefinite amount of further inquiry along the lines that it has opened up.

Heidenhain conducted his investigations on medical men and students as his subjects, one of them being his brother. He found that, in the first or least profound stage of hypnotism, the patient, on being awakened, can remember all that happened during the state of mesmeric sleep; on awakening from the second or more profound stage, the patient can only partially recollect what has happened; while in the third, or most profound stage, all power of subsequent recollection is lost. But, during even the most profound stage, the power of sensory perception remains. The condition of the patient is then the same, so far as the reception of sensory impressions is concerned, as that of a man whose attention is absorbed or distracted; he sees sights, hears sounds, etc., without *knowing* that he sees or hears them, and he can not afterward recollect the impressions that were made. But the less profound stages of hypnotism are paralleled by those less profound conditions of reverie in which a passing sight or sound, although not noticed at the time, may be subsequently recalled by an effort of the will. Further on in his treatise Heidenhain tells us that, even when all memory of what has passed during the hypnotic state is absent on awakening, it may be aroused by giving the patient a clew, just as in the case of a forgotten dream. This clew may consist only

"* Der sogenannte thierische Magnetismus." Physiologische Beobachtungen, von Dr. Rudolf Heidenhain, ord. Professor der Physiologie und Director der physiologischen Institutes zu Breslau. (Breitkopf und Härtel, Leipsic, 1880.)

of a single word in a sentence. Thus, for instance, if a line of poetry is read to a patient during his sleep, the whole line may sometimes be recalled to his memory, when awake, by repeating a single word of the line. Again, we know from daily experience that the most complicated neuro-muscular actions—such as those required for piano-playing—become by frequent repetition "mechanical," or performed without consciousness of the processes by which the result is achieved. So it is in the case of hypnotism. Actions which have been previously rendered mechanical by long habit are, in the state of hypnotism, performed automatically in response to their appropriate stimuli. There being a strong tendency to imitate movements, these appropriate stimuli may consist in the operator himself performing the movements. Thus when Heidenhain held his fist before his hypnotized subject's face, his subject immediately imitated the movement; when he opened his hand his subject did the same, provided that his hand was visible to his subject at the time. Also, when he clattered his teeth, the hypnotized patient repeated the movement, even though the patient could only hear, and not see, the movement; similarly, the patient would follow him about the room, providing that in walking he made sufficient noise to constitute a stimulus to automatic walking on the part of his patient. In order to constitute stimuli to such automatic movements, the sounds or gestures must stand in some such customary relation to the movements that the occurrence of the former naturally suggests the latter.

Another characteristic of the hypnotic state is that of an extraordinary exaltation of sensibility, so that stimuli of various kinds, although much too feeble to evoke any response in the ordinary condition of the nervous system, are effective as stimuli in the hypnotic condition. It is remarkable that this state of exalted sensibility should be accompanied by what appears to be a lowered, or even a dormant, state of consciousness. It is also remarkable that this exaltation of sensibility does not appear to take place with what may be called a proportional reference to all kinds of stimuli. Indeed, far from there being any such proportional reference, the greatly exalted state of sensibility toward slight stimuli is accompanied by a greatly diminished state of excitability toward strong stimuli. Thus, deeply hypnotized persons will allow themselves to be cut, or burned, or to have pins stuck into their flesh, without showing the smallest signs of discomfort. Heidenhain is careful to point out the interesting similarity, if not identity, between this condition and that which sometimes occurs in certain pathological derangements of the central nervous system, as well as in a certain stage of anæsthesia, wherein the patient is able to feel the contact of the surgical instruments, while quite insensible to any pain produced by the cutting of his flesh. Reflex sensibility, or sensibility conducing to reflex movements, also undergoes a change, and it does so in the direction of increase, as might be expected from

the consideration that with the temporary abolition of consciousness the inhibitory influence, which we know the higher nerve-centers to be capable of exerting upon the lower, is presumably suspended. But quite unanticipated is the remarkable fact that the state of exalted reflex excitability may persist for several days—perhaps for a week—after a man has been aroused from a state of profound hypnotism. Thus, Dr. Krener, after having been hypnotized by Professor Heidenhain, and while asleep made to bend his arm twice, for several days afterward was unable again to straighten it, on account of the flexor muscles continuing in a state of tonic contraction, or cramp. In these experiments Heidenhain found that a very gentle stimulation of the skin caused only the muscles lying immediately below the seat of stimulation to contract, and that on progressively increasing the strength of the stimulus its effect progressively spread to muscles and to muscle-groups farther and farther removed from the seat of stimulation. It is interesting that this progressive spread of stimulation follows almost exactly Professor Pflüger's law of irradiation. But the rate at which a reflex excitation is propagated through the central-nerve organs is very slow, as compared with the rapidity with which such propagation takes place in ordinary circumstances. Moreover, the muscles are prone to go into tonic contraction, rather than to respond to a stimulus in the ordinary way. The whole hypnotic condition thus so strongly resembles that of catalepsy that Heidenhain regards the former as nothing other than the latter artificially induced. In the case of strong persons this tonic contraction of the muscles may make the body as stiff as a board, so that, if a man is supported in an horizontal position by his head and his feet only, one may stand upon his stomach without causing the body to yield. The rate of breathing has been seen by Heidenhain to be increased fourfold, and the pulse also to be accelerated, though not in so considerable a degree.

In a chapter on the conditions which induce the state of hypnotism, Heidenhain begins by dismissing all ideas of any special "force" as required to produce or to explain any of the phenomena which he has witnessed. He does not doubt that some persons are more susceptible than others to the influences which induce the hypnotic state, and he thinks that this susceptibility is greatest in persons of high nervous sensibility. These "influences" may be of various kinds; such as looking continuously at a small bright object, listening continuously to a monotonous sound, submitting to be gently and continuously stroked upon the skin, etc.—the common peculiarity of all the influences which may induce the hypnotic state being that they are sensory stimuli of a gentle, continuous, and monotonous kind. Awakening may be produced by suddenly blowing upon the face, slapping the hand, screaming in the ear, etc., and even by the change of stimulus proceeding from the retina which is caused by a person other than the operator suddenly taking his place before the patient. On the whole, the hyp-

notic condition may be induced in susceptible persons by a feeble, continued, and regular stimulation of the nerves of touch, sight, or hearing ; and may be terminated by a strong or sudden change in the stimulation of these same nerves.

The physiological explanation of the hypnotic state which Heidenhain ventures to suggest is, that a stimulus of the kind just mentioned has the effect of inhibiting the functions of the cerebral hemispheres, in a manner analogous to that which is known to occur in several other cases which he quotes of ganglionic action being inhibited by certain kinds of stimuli operating upon their sensory nerves.

In a more recent paper, embodying the results of a further investigation in which he was joined by P. Grutzner, Heidenhain gives us the following supplementary information :

The muscles which are earliest affected are those of the eyelids ; the patient is unable to open his closed eyes by any effort of his will. Next, the affection extends in a similar manner to the muscles of the jaw, then to the arms, trunk, and legs. But even when so many of the muscles of the body have passed beyond the control of the will, consciousness may remain intact. In other cases, however, the hypnotic sleep comes on earlier.

Imitative movements become more and more certain the more they are practiced, so that at last they may be invariable and wonderfully precise, extending to the least striking or conspicuous of the changes of attitude and general movements of the operator. Professor Berger observed that, when pressure is exerted with the hand at the nape of the neck upon the spinous process of the seventh cervical vertebra, the patient will begin to imitate spoken words. It is immaterial whether or not the words make sense, or whether they belong to a known or to an unknown language. The tone in which the imitation is made varies greatly in different individuals, but for the same individual is always constant. In one case it was a hollow tone, "like a voice from the grave" ; in another almost a whisper, and so on. In all cases, however, the tone is continued in one kind, i. e., it is monotonous. Further experiments showed that pressure on the nape of the neck was not the only means whereby imitative speaking could be induced, but that the latter would follow with equal certainty and precision if the experimenter spoke against the nape of the neck—especially if he directed his words upon it by means of a sound-funnel. A similar result followed if the words were directed against the pit of the stomach. It followed with less certainty when the words were directed against the larynx or into the open mouth, and the patient remained quite dumb when the words were directed into his ear, or upon any other part of his head. If a tuning-fork were substituted for the voice, the note of the fork would be imitated by the patient when the end of the fork was placed on any of the situations just mentioned as sensitive. By exploring the pit of the stomach with a tuning-fork, the sensitive area

was found to begin about an inch below the breastbone, and from thence to extend for about two inches downward and about the same distance right and left from the middle line, while the navel, breastbone, ribs, etc., were quite insensitive. Heidenhain seeks—though not, we think, very successfully—to explain this curious distribution of areas sensitive to sound, by considerations as to the distribution of the vagus nerve.

Next we have a chapter on the subjection of the intellectual faculties to the will of the operator which is manifested by persons when in a state of hypnotism. For the manifestation of these phenomena the sleep must be less profound than that which is required for producing imitative movements; in this stage of hypnotism the experimenter has not only the motor mechanism on which to operate, but likewise the imagination. "Artificial hallucinations" may be produced to any extent by rehearsing to the patient the scenes or events which it may be desired to make him imagine. A number of interesting details of particular cases are given, but we have only space to repeat one of the most curious. A medical student, when hypnotized in the morning, had a long and consecutive dream, in which he imagined that he had gone to the Zoölogical Gardens, that a lion had broken loose, that he was greatly terrified, etc. On the evening of the same day he was again hypnotized, and again had exactly the same dream. Lastly, at night, while sleeping normally, the dream was a third time repeated.

A number of experiments proved that stimulation of certain parts of the skin of hypnotized persons is followed by certain reflex movements. For instance, when the skin of the neck between the fourth and seventh cervical vertebræ is gently stroked with the finger, the patient emits a peculiar sighing sound. The similarity of these reflex movements to those which occur in the well-known "croak-experiment" of Goltz is pointed out.

A number of other experiments proved that unilateral hypnotism might be induced by gently and repeatedly stroking one side or other of the head and forehead. The resulting hypnotism manifested itself on the side opposite to that which was stroked, and affected both the face and limbs. When the left side of the head was stroked, there further resulted all the phenomena of aphasia, which was not the case when the right side of the head was stroked. When both sides of the head were stroked, all the limbs were rendered cataleptic, but aphasia did not result. On placing the arms in Mosso's apparatus for measuring the volume of blood, it was found that, when one arm was hypnotized by the unilateral method, its volume of blood was much diminished, while that of the other arm was increased, and that the balance was restored as soon as the cataleptic condition passed off. In these experiments consciousness remained unaffected, and there were no disagreeable sensations experienced by the patient. In some instances,

however, the above results were equivocal, catalepsy occurring on the same side as the stroking, or sometimes on one side and sometimes on the other. In all cases of unilateral hypnotism, the side affected as to motion is also affected as to sensation. Sense of temperature under these circumstances remains intact long after sense of touch has been abolished. As regards special sensation, the eye on the hypnotized side is affected both as to its mechanism of accommodation and its sense of color. While color-blind to "objective colors," the hypnotized eye will see "subjective colors" when it is gently pressed and the pressure suddenly removed. Moreover, if a dose of atropine be administered to it, and if it be then from time to time hypnotized while the drug is gradually developing its influence, the color-sense will be found to be undergoing a gradual change. In the first stage yellow appears gray with a bluish tinge, in the second stage pure blue, in the third blue with a yellowish tinge, and in the fourth yellow with a light-bluish tinge. The research concludes with some experiments which show that in partly hypnotized persons imitative movements take place involuntarily, and persist until interrupted by a direct effort of the will. From this fact Heidenhain infers that the imitative movements which occur in the more profound stages of hypnotism are purely automatic, or involuntary.

In concluding this brief sketch of Heidenhain's interesting results, it is desirable to add that in most of them he has been anticipated by the experiments of Braid. Braid's book is now out of print, and, as it is not once alluded to by Heidenhain, we must fairly suppose that he has not read it. But we should be doing scant justice to this book if we said merely that it anticipated nearly all the observations above mentioned. It has done much more than this. In the vast number of careful experiments which it records—all undertaken and prosecuted in a manner strictly scientific—it carried the inquiry into various provinces which have not been entered by Heidenhain. Many of the facts which that inquiry yielded appear, *a priori*, to be almost incredible; but, as their painstaking investigator has had every one of his results confirmed by Heidenhain so far as the latter physiologist has prosecuted his researches, it is but fair to conclude that the hitherto unconfirmed observations deserve to be repeated. No one can read Braid's work without being impressed by the care and candor with which, amid violent opposition from all quarters, his investigations were pursued; and now, when, after a lapse of nearly forty years, his results are beginning to receive the confirmation which they deserve, the physiologists who yield it ought not to forget the credit that is due to the earliest, the most laborious, and the hitherto most extensive investigator of the phenomena of what he called hypnotism.—*Nineteenth Century.*

SKETCH OF LEWIS H. MORGAN,

PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

BY J. W. POWELL.

LEWIS HENRY MORGAN was born near the village of Aurora, New York, November 21, 1818. The subject of this sketch is eight generations in lineal descent on his father's side from James Morgan, who settled in Roxbury, Massachusetts, in 1646 ; and on his mother's side from John Steele, who settled in Newton, now Cambridge, in 1641 ; beginning with these, seven generations of his ancestors have lived and died in New England.

In 1840, at the age of twenty-one, young Morgan graduated at Union College, and was engaged in the study of law until 1844. During this time he occasionally wrote articles for the "Knickerbocker" and other periodicals. On his return to Aurora from college he was induced to join a secret society composed of young men of that place. This trivial circumstance had a great influence on his future career. The society was organized for no definite purpose, and failed to interest young Morgan, who at once looked about for some method of expanding the society and extending its influence ; and finally, under his management, a new society was organized and styled "The Grand Order of the Iroquois." The plan was to model it somewhat after the pattern of Indian tribes, and to extend the organization over all the territory occupied by the Iroquois, and to have a group of branch societies for each area occupied by an Iroquois tribe, or nation, as they were then called, and these larger divisions divided into chapters as Indian nations were divided into gentes—so-called tribes.

In order that this new organization might be properly formed on the plan of the ancient Iroquois confederacy, young Morgan went among the Indians of New York for the purpose of studying their social organization and government. In this he soon became deeply interested, as did many of the originators of "The Grand Order of the Iroquois." A number of the gentlemen who took part in the organization of the society have since risen to important positions in American society, as a mention of the following names will demonstrate : Rev. Isaac N. Hurd ; Henry Haight, afterward Governor of California ; the late General Albert J. Myer, Chief of the Signal Service ; Hon. George Barker, Justice of the Supreme Court of New York ; the late Judge Charles P. Avery, of Oswego ; the late Hon. Charles Billinghurst, member of Congress from Wisconsin ; Rev. Anson J. Upton, President of the Auburn Theological Seminary ; Charles T. Porter, of Philadelphia ; Hon. Theodore Pomeroy, of Auburn ; William Allen, of Auburn ; C. White, of Aurora ; the late Frederick De Lano, of Rochester ; the late Alexander Mann, of Rochester ; Hon.

Stephen Goodwin, of Chicago; Rev. James S. Bush, of Staten Island; and George S. Riley, of Rochester.

The society seems to have greatly flourished for a time, and to have been very popular throughout that portion of New York west of the Hudson River. Its ceremonies were picturesque and attractive. The meetings of the society were called councils, and were held in the woods. The Grand Council was held in a forest near Aurora by night, and the forest aisles were illuminated by huge camp-fires, and the sachems and chiefs who there assembled came in Indian panoply, with chaplets of eagle-feathers, Indian tunics, scarlet leggins, and decorated moccasins. It was wild sport, in which the young men engaged in merry mood.

Morgan and his young associates soon became absorbed in active business, and found that the society they had organized could not be operated without consuming too great a portion of their time, and it died by premeditated neglect. But the discoveries made by Morgan were of such importance and interest that he continued his investigations from time to time, and, in order to obtain a deeper insight into the home life and customs of the Indians, and their social and governmental organization, he spent much time among them and was adopted into a gens of the Senecas.

In 1847 he published in the "American Review" a series of "Letters on the Iroquois," over the signature of "Skenandoah." In the mean time he was building up a legal practice, and found that he must neglect it or abandon his studies of Indian life and government; and so he determined to publish the materials on hand, and then devote himself exclusively to the practice of his profession. This resulted in the publication in 1851 of "The League of the Iroquois," in which the social organization and government of this wonderful confederacy were carefully and thoroughly explained. The volume also contains interesting accounts of the daily life, customs, and superstitions of these Indians, and was the first scientific account of an Indian tribe ever given to the world.

The work is not entirely free from the nomenclature of sociology previously, and to some extent since, used by writers on our North American Indians, in which tribes are described as nations, and the institutions of tribal or barbaric life defined in terms used in national or civilized life. But the series of organic units was discovered among the Iroquois and was correctly defined, though the confederacy was called a league, the tribe a nation, and the gens a tribe. In like manner, kinship as the bond of union was fully recognized.

In 1856 Morgan attended the Albany meeting of the American Association for the Advancement of Science, and read a paper called "The Laws of Descent of the Iroquois." The reading of the paper awakened great interest in the subject, and a number of the leading members of the Association urged Mr. Morgan to continue his studies

in this field. Professors Henry and Agassiz were especially urgent in the matter, and Morgan decided to return to his old studies, but rather as an amateur and in such a manner as not to interfere with his profession.

In 1858 he was at Marquette, where he found an encampment of Ojibwa Indians, and, going into a tent, sat down with an Indian, and gradually in conversation drew from him an account of the Ojibwa system of kinship, the list of gentes, and the gentile organization of the tribe, and found them essentially the same as the Iroquois.

To him this was a great surprise, for up to this time he had supposed that the Iroquois Confederacy had a system peculiar to itself and was an anomaly among governments. But here he found society and government organized upon the same plan, and yet the linguistic terms were totally different. He had thus discovered the essential characteristic of tribal government in two distinct stocks of our North American Indians, and it occurred to him that the system might extend further, so he determined to pursue his investigations among other Indians.

On his return to Rochester he took up "Riggs's Dakota Grammar and Dictionary," then lately published by the Smithsonian Institution, and found in the kinship terms as therein defined evidences of the same kinship system. He then more carefully examined the English and Roman systems, especially as they are set forth by Blackstone and in the Pandects of Justinian. Finally, he prepared schedules of inquiry to be circulated among missionaries, teachers, traders, and other persons familiar with Indian life.

At this stage Professor Henry became deeply interested in the investigations and published the schedules for Mr. Morgan, which were widely distributed in America and throughout the world by the Smithsonian Institution and by the active coöperation of General Cass, who was then Secretary of State.

During the earlier years Mr. Morgan was greatly disappointed with the returns from the circulation of these schedules. The subject was new and strange, and the persons to whom they were sent were slow in comprehending the nature and value of the researches suggested; and so he determined to pursue his investigations in person, and for this purpose in 1859 he made an expedition through Kansas and Nebraska. In 1860 he went over the same ground, revising his former work, increasing his observations, and extended his journey far up the Missouri River. In 1861 he made a trip to the Hudson Bay Territory and Lake Winnipeg, and in 1862 to Fort Benton and the Rocky Mountains.

In his travels he everywhere sought the Indian tribes, and through the aid of interpreters—white men and Indians—filled out his own schedules and extended his studies into the social life and government of the Indians and other collateral branches of anthropology.

Finally, returns from his schedules of inquiry began to pour in from all quarters of the globe, and gradually a vast correspondence grew up, until the kinship systems of more than four fifths of the world were recorded either directly by himself or by others whom he had enlisted in the work. The materials thus collected were gradually by years of labor thoroughly systematized, and finally published by the Smithsonian Institution as one of its "Contributions to Knowledge," entitled "Systems of Consanguinity and Affinity of the Human Family." It is a quarto volume of about six hundred pages, the result of many years of patient and well-directed labor, and it constitutes a model of inductive research. The kinship systems of eighty tribes of North America, together with those of a great number of the principal nations and tribes of the Old World and the islands of the sea, are fully and elaborately recorded in its tables.

This publication marks a most important epoch in anthropologic research. Prior to its appearance, the social and governmental institutions of mankind antecedent to the evolution of civilization were to a large extent unknown. Travelers and various persons more or less familiar with tribal life had put on record many curious facts, and the compilation of these facts by scholars had resulted in the accumulation of incoherent and inconsistent materials about which more or less crude and fanciful speculations were made ; but the essential characteristics of tribal society, as based upon kinship in barbarism and upon communal marriage in savagery, were unknown.

This first volume was essentially a volume of facts, and only a brief and rather unsatisfactory discussion of the facts was undertaken. Mr. Morgan's final conclusion and philosophic treatment of the subject were reserved for a subsequent volume.

During the earlier years of Morgan's work upon the "Systems of Consanguinity and Affinity," he carried on an extensive law business, and was engaged in a railroad enterprise upon the Michigan Peninsula. The latter necessitated frequent visits to what was then a forest wilderness on the shores of Lake Superior, and here he became interested in the study of the beaver, which resulted in the publication, in 1868, of a volume entitled "The American Beaver and his Works." In his preface to this volume Mr. Morgan thus describes the circumstances under which these studies were made :

Having been associated in this enterprise from its commencement, as one of the directors of the railroad company, and as one of its stockholders, business called me to Marquette first in 1855, and nearly every summer since to the present time. After the completion of the railroad to the iron-mines, it was impossible to withstand the temptation to brook-trout fishing, which the streams traversing the intermediate and adjacent districts offered in ample measure. My friend Gilbert D. Johnson, Superintendent of the Lake Superior Mine, had established boat-stations at convenient points upon the Carp and Esconauba Rivers, and to him I am specially indebted, first, for a memorable experience in brook-trout fishing, and, secondly, for an introduction to the works of the beaver

within the areas traversed by these streams. Our course, in passing up and down, was obstructed by beaver-dams at short intervals, from two to three feet high, over which we were compelled to draw our boat. Their numbers and magnitude could not fail to surprise as well as interest any observer. Although constructed in the solitude of the wilderness, where the forces of Nature were still actively at work, it was evident that they had existed and been maintained for centuries by the permanent impression produced upon the rugged features of the country. The results of the persevering labors of the beaver were suggestive of human industry. The streams were bordered continuously with beaver meadows, formed by overflows by means of these dams, which had destroyed the timber upon the adjacent lands. Fallen trees, excavated canals, lodges, and burrows, filled up the measure of their works. These together seemed to me to afford a much greater promise of pleasure than could be gained with the fish-pole, and very soon, accordingly, the beaver was substituted for the trout. I took up the subject, as I did fishing, for summer recreation. In the year 1861 I had occasion to visit the Red River settlement in the Hudson's Bay Territory, and in 1862 to ascend the Missouri River to the Rocky Mountains, which enabled me to compare the works of the beaver in these localities with those on Lake Superior. At the outset I had no expectation of following up the subject year after year, but was led on by the interest which it awakened, until the materials collected seemed to be worth arranging for publication. Whether this last surmise is well or ill founded, I am at least certain that no other animal will be allowed to entrap the unambitious author so completely as he confesses himself to have been by the beaver. My unrestrained curiosity has cost me a good deal of time and labor.

Morgan's researches among the tribes of North America were extended to many subjects not included in the great volume published by the Smithsonian Institution. The results of these collateral investigations led to the publication of a series of articles in the "North American Review." The first appeared in 1869, and was entitled "The Seven Cities of Cibola," in which he comes to the qualified conclusion that the ruins on the Chaco in New Mexico represent what remains to us of the so-called cities described by the ancient Spanish travelers. Incidentally, the paper also contains a careful description of pueblo architecture, and its relation to gentile life, and is compared with the architecture of old Mexico; and the statement is made that the buildings discovered by the Spaniards in Mexico were in fact pueblos, or communal dwellings, but were exaggerated by them into palatial residences of emperors, with retinues of serving lords and hosts of slaves. The lengthy article closes with the following paragraph:

When the romantic features of the discovery and conquest of Mexico, which made such a powerful impression upon the writers of the sixteenth and seventeenth centuries, and which have not yet lost their influence, shall become softened down by our increasing knowledge of Indian character, arts, and institutions, it will be possible to reconstruct, from existing materials, a rational history of this interesting people. If the author of the volume, whoever he may be, will entitle his work 'A History of the Aztec Confederacy,' and, after explaining the political relations of the three nations of which it was composed, and the functions of the council by which it was governed, will then introduce Montezuma

as the head chief of the Aztecs, one of the three confederated peoples, the reader will be certain to start with a tolerably clear impression. No harm will be done to truth, if the great lords, with many vassals and large landed estates, and the little lords, with few vassals and small landed estates, are introduced as plain Indian chiefs, innocent of all knowledge both of estates and vassals. Besides this, it is not improbable that the palaces and most of the temples will ultimately resolve themselves into plain communal houses, like those now standing in the picturesque and beautiful valley of the Chaco, roofless and deserted. With these, and a number of similar changes, the future student of aboriginal history will not be led to deceptive conclusions by the glitter of inappropriate terms. Such a history is due to the memory of the Aztecs, and to a right estimate of the Indian family.

This article inaugurated the reconstruction of the history of Mexican and Central American culture, which is now rapidly in progress. All the previous history had a been a vain but brilliant exaggeration of Indian society, with its languages, arts, religion, and social and governmental institutions—a picture derived from boastful and mendacious travelers.

In the latter part of 1869 a second article appeared in the same journal on Indian migrations, followed by a third on the same subject in 1870. The purpose of these articles was to indicate an original general dispersion of the Indian tribes from the region of the Columbia River.

In 1876 a fourth article appeared, entitled "Montezuma's Dinner," which was in part a review of Bancroft's "Native Races of the Pacific States," but in fact was a general characterization of the culture discovered in Mexico and Central America, with a review of the historic evidence, and was an exquisite satire on the exaggerated accounts of Spanish travelers and priests, expanded and glorified by modern writers.

In the same year a fifth article appeared, on the "Houses of the Mound-Builders."

The great work of Mr. Morgan was yet unpublished. It remained for him to gather the materials he had collected on tribal society into one philosophic treatise. This was accomplished in the publication of his volume entitled "Ancient Society" in 1877. This was divided into four parts, as follows: Part I. Growth of Intelligence through Inventions and Discoveries; Part II. Growth of the Idea of Government; Part III. Growth of the Idea of the Family; Part IV. Growth of the Idea of Property.

In the first part technologic evolution was discussed, and culture periods, or what Mr. Morgan denotes "ethnical periods," were defined. These grand periods, through which the most highly developed races of mankind have passed, and into which the various peoples on the globe may be distributed, were set forth as the savage, the barbaric, and the civilized. These were defined in terms relating to the evolution of arts. Savagery and barbarism were divided into three periods

each, giving the lower, middle, and upper status of savagery, and the lower, middle, and upper status of barbarism; these subdivisions also being established on the development of specified arts.

Two grand plans of government are also set forth—tribal and national; tribal government being personal, i. e., taking into account persons only, and national government being territorial and based on property.

In the second part he discussed in a thorough manner the different forms of government in the order of their evolution, beginning with the organization of society upon the basis of sex, as it is found in Australia, and fragments of which are found as survivals among other tribes of the world. He then expounded the organization of society and tribal governments based upon kinship; and having by wide research discovered this system in every quarter of the globe among people living in barbaric life, and having discovered by abundant evidence that the same form of society and government existed in the early history of the most civilized peoples, he logically inferred that gentile society and tribal government as based upon kinship are the universal characteristic of man in his passage through the period of barbarism. He also discussed the evolution of gentile society from connubial society; defined the organic units of tribal government as gentes, phratries, tribes, and confederacies, pointing out their origin and growth as illustrated by abundant examples throughout the globe; and, finally, the evolution of gentile society and tribal government into property society and national government.

In Part III he treats of the evolution of the family—discovers five successive forms, and sets forth the processes by which the first or consanguineal family, which is founded upon the intermarriage of brothers and sisters, own and collateral in a group, was developed into the last or monogamian, which is founded upon marriage by single pairs with exclusive cohabitation. In the final chapter of this part he gives the sequence of institutions connected with the family in tabular form with appended explanations.

In the fourth part Mr. Morgan deals with the origin of civilization. Discovery and invention finally led to the accumulation of property, and society was organized on this basis; and for the protection of property and the industries by which it is produced civilized governments have finally been established over territorial areas. The growth of the idea of property with the development of industries is explained, together with the evolution of laws of inheritance.

Thus the plan of Mr. Morgan's great work was completed. In it was laid the foundation for the science of government as it is finally to be erected by the philosophy of evolution.

In the progress of human culture institutions are developed; new rights with their correlative duties arise from the new relations into which men are placed. For the maintenance of these rights and the

enforcement of these duties, governments change in all their substantial characteristics, and the great laws of evolution in the processes of differentiation and integration are followed, as tribes integrate into nations and the functions of government are differentiated ; communal industries change to individual and corporate industries ; communal property to individual and corporate property ; communal marriage to individual marriage ; communal government to organized national government, with the differentiation of the three great departments, the executive, the legislative, and the judicial ; and these again elaborately differentiated with special organic members for special organic functions—all progressing with advancing intelligence to secure justice and thereby increase happiness.

This survey of governments in their totality presents one fact of profound interest to statesmen. Government by the people is the normal condition of mankind, as a broad review of human history abundantly maintains. Monarchies are temporary phases of government in the evolution of mankind from barbarism to civilization ; and these monarchies with their attendant hierarchies, feudalisms, and slavery, appear only as pathologic conditions of the body politic—diseases which must be destroyed or they will destroy—and hence disappearing by virtue of the survival of the fittest. Hope for the future of society is the best-beloved daughter of Evolution.

Morgan has here been spoken of as a pioneer in a special field of research, but many others worked contemporaneously with him in the same field. Notable among these are Tylor and Maine, whose fields of investigation were, to some extent, identical with Morgan's ; though in a larger sense, the areas which they covered were diverse. Where their studies were in common their methods of research were diverse. Maine and Tylor ransacked recorded history. Morgan plunged into the wilderness and studied Indian tribes, but his plan also included the study of annals ; yet his work is largely made up of a record of facts previously unknown to science.

Long years of excessive labor, with sorrows that invade the domestic circle through disease and death, have somewhat decreased the vigor of physical life not long ago so characteristic of the man. On account of his infirmities he presided with some difficulty at the last meeting of the American Association for the Advancement of Science ; but his mental vigor continues, and he is now engaged in the preparation of a volume on the "House Life and Architecture of the North American Indians," to be published by the Bureau of Ethnology of the Smithsonian Institution.

May his years continue and his works multiply ! It is not one of the least of the results accomplished by Mr. Morgan that he has gathered about him loving disciples who are reaping harvests from fields planted by himself.

CORRESPONDENCE.

SCIENCE AT PRINCETON COLLEGE.

Messrs. Editors.

THERE are statements in the "Correspondence" of the last number of "The Popular Science Monthly" fitted to leave an unjust impression as to what is taught in Princeton College. I do not enter upon the argument of that article, which is palpably illogical. It is that we have had low fever, taking a typhoid shape, because we do not teach physiology to our students. Two scientific adepts have reported as to our sanitary state, and what they have testified is likely to be accepted by the public. Nor do I look on this as the fitting opportunity to enter on the discussion as to what branches should be taught in colleges which impart a high and refining education, and confer the Bachelor's, the Master's, and the Doctor's degrees. My opinions on this subject have often been given to the world. I believe that, in our higher educational institutions, there should be a due combination of literature (including languages), of science, and philosophy. We have endeavored to unite these, and give a proper place to each in our curriculum. It is only thus that we can fulfill the grand end of education, that of developing the man and the full man. I do not regard a youth as fully trained who knows merely Latin and Greek; but as little do I look upon him as educated if he knows only his own bodily frame and malarial disease. Nor am I ashamed to add that religion has an important part to act in a college, if we would impart the proper spirit to our young men. The favorites of "The Popular Science Monthly," Professor Huxley and Herbert Spencer, have avowed that there is no adequacy in physical science to make youths moral; and the former wishes the Bible taught in the public schools of London, and the latter seems to be trusting to a development which will make people moral in a million of years, if in the mean time the world is not burnt up by the conflagration which he says must come. But my special object in this communication is to correct certain statements and insinuations as to our teaching. The impression is left by the article that we give exclusive, or, at least, our chief attention, to classics and certain old branches, and that we neglect the study of our own bodily frame and of the laws of health. After this declaration, your readers may be surprised to learn that of our thirty instructors thirteen are employed in teaching the various sciences, including the very latest. As to the special branches which we are said not to teach, the Professor of General Chemistry reports: "All students of the college have a full course of instruction in the outlines of human anatomy and physiology, with so much of hygiene as there is time for; and this has been done in the college for nearly half a century. We do not profess to be a medical college, or to train physicians, but no student leaves us without a fair knowledge of his own bodily system." The Professor of Analytical Chemistry reports: "The question of sewage, from a chemical point of view, is fully investigated by all the students of the scientific course and by those of the academic course who elect applied chemistry. Its injurious effects on the atmosphere and on the water are described and the laws of the diffusion of all gases are applied at this present time, and have always been, to this question." The Professor of Natural History writes: "The students in science go through a course of physiology, using 'Huxley's Elements' as a text-book, along with '*Youmans's Chapters on Hygiene*,' to which special attention is given. The subjects which are said to be neglected are all taught with some degree of fullness." I have an idea that some of the readers of "The Popular Science Monthly" will be gratified to notice that Professor Youmans is allowed to teach hygiene to our young men; but they will also discover that this fact undermines his argument, which is that, where hygiene is taught, there should be no fever.

JAMES McCOSH.

PRINCETON COLLEGE, *August* 14, 1880.

THE SENSE OF DIRECTION IN ANIMALS.

Messrs. Editors.

I WAS very much interested in the account, published in your July number, of the experiments with the intelligent Cincinnati dog, and I think the facts there developed tend strongly to the proof of a theory that I have long believed to be correct, viz., that some of the lower animals are endowed with a sense of location and direction which at most is only rudimentarily possessed by man. I do not think that the feats of the carrier-pigeon can be accounted for on the theory of any finite

development of the sense of sight, smell, or hearing, and the action of honey-bees presents the same difficulties to persons familiar with the habits of these interesting insects. In searching for wild honey, the bee-hunter provides himself with a small box with a sliding door; inside of this box he puts some sweet substance as a bait for the bees. When several bees have collected in the box, he closes the lid. As soon as they have finished eating, he releases a bee, which, after ascending high enough to clear the surrounding trees, makes a "bee-line" for its hive. The hunter marks this direction and carries his box off at right angles to the line made by the first bee, and releases another bee; he carefully marks the direction taken by this second bee, and, if they are both from the same swarm, the hive will be found at the point where these two lines meet.

I might cite well-authenticated cases of cats, pigs, and dogs, finding their way home, where such a feat would seem impossible to man under like circumstances; my object, however, was not to theorize, but simply to record what I consider some interesting observations bearing upon this subject.

Last spring I built a trout-pond in my garden, on the west side of a running brook discharging about six hundred cubic feet of water per minute. The brook is quite rapid where it passes the pond, and the surface of the pond is some five feet higher than the surface of the brook. The pond is supplied with water brought 2,000 feet in underground pipes and discharged in a fountain in the center of the pond. Common bull-frogs (*Rana pipiens*) occasionally find their way into this pond. On the 18th of last July I found three frogs in the pond, and shot all of them with a pistol. I dipped them up with a scoop-net, and found two of them shot through the body, and the other, a little fellow, weighing about two ounces, was shot across the back, the bullet just raising the skin and leaving a white streak across its dark-green surface. I emptied the three frogs out of the net into the swift-running water of the brook, and they floated down stream out of sight. On the 19th of July, the day following, I found the wounded frog in the pond again, and readily recognized it by the scar from the bullet. I found no difficulty in catching it in the scoop-net, and, fearing that the scar might disappear from its back, I cut off the center toe of its right foot, put the frog into a paper bag, carried it down the brook across a bridge, and finally threw it into the stream some one hundred yards below the pond.

On the 21th of July I found the frog back again, caught it, and, so as to leave no doubt about its identification, I cut off the middle toe of the left foot. I then put the frog in the paper bag, started from the pond in a northeast course, stopped and whirled the bag around so as to confuse any ideas that it might have had of direction, and then changed my course, and finally released the frog on the opposite side of the brook in an oat-field about an eighth of a mile in an easterly direction from the pond. To prevent the frog from getting any idea from watching me, I passed on after releasing it, and did not go back again to the pond for several hours. Three days afterward I saw the frog in the pond again, but it was so wild that I could not catch it with my scoop-net, and I afterward tried various devices to capture it alive, but the moment it saw me approach the pond it would jump in and remain hidden in the stones at the bottom until I left. Finally, despairing of catching it alive, and having some doubts about its identity, on the 9th of August I shot it, and recognized it by the absence of the cut-off toes.

The general direction is up-hill from the point where the frog was last released to the pond, and about the same distance in a down-hill course would have taken the frog to the Ausable River. It still remains possible that the frog waited until night, and then followed my tracks back to the pond, but that seems improbable, I think, even more so than to believe that the frog knew all the time the direction of the pond, and slowly worked its way back again as inclination prompted.

George Chahoon.

Ausable Forks, New York, *August* 16, 1880.

SCIENCE AT THE UNIVERSITY OF MICHIGAN.

Messrs. Editors.

My eye has just fallen on your editorial comments under the head of "Sewage in College Education"; and I can not resist the impulse to point out a few of the errors into which you have been drawn. Not much space will be required, I think, to show that the attitude of the University of Michigan toward scientific and classical studies has been quite misapprehended.

In the first place, you are in error in assuming that Bishop Harris spoke as the representative of the University. Would it have been fair to assume that Yale College was represented by President White's famous address on the "Warfare of Science"? Each of these gentlemen was invited to deliver a commencement address, each chose his own subject, each treated his subject in his own way, and each was alone responsible for what he said. One sentence in the Bishop's address may have misled you. I refer to that in which he expressed his gratitude that classical studies still maintain their

prominence in this university. But it is certain that the Bishop either meant simply to express his satisfaction that so large a number of students still continue to pursue classical studies, notwithstanding the inducements held out by the scientific courses, or, what is perhaps quite as likely, he himself was not fully aware of what the University is doing for the encouragement of scientific pursuits. In one instance, at least, the Bishop ran squarely athwart all the traditions and usages of the University. The orator indicated certain studies which he would not permit the student to pursue. The University, on the contrary, has long held up as its ideal: "All learning and that of the best"; and entire freedom of choice on the part of students as to what they would pursue.

You remark: "This great institution, with its fourteen hundred students, seems just as much enslaved by vicious traditions as the older schools. Middle-Age studies are still in the ascendant. The sciences are taught there, but the classical course is the one encouraged by the whole weight of the University influence."

I think a few facts will be enough to show you that this assertion is totally and comprehensively incorrect.

1. As many as twenty-eight years ago *the University of Michigan was the pioneer* in the work of raising scientific studies to a footing of absolute equality with the old classical curriculum. At that moment there was not a single college or university in the country that had a scientific course of four years. Such a four years' course was then established here; it has ever since been maintained, and the requisites for admission to it have been raised as rapidly as the condition of the preparatory schools would permit.

2. *The work, thus early begun, has gone steadily on to the present day.* Besides the various professional degrees in engineering, the University now confers four degrees as the reward of four years of successful study, viz.: Bachelor of Arts, Bachelor of Science, Bachelor of Philosophy, and Bachelor of Letters. The ancient languages are required for the first of these degrees only; and even for A. B. the amount of Latin and Greek required aggregates only about one solid year's work, while the amount of science required aggregates scarcely less, and the amount of science the student may elect in addition aggregates the work of two full years. Thus, even in the classical course, the student with his one year of classics may, if he choose, take two and a half years of science.

3. The number of courses of instruction in Latin and Greek offered to students the present semester is twelve (12), while the number of courses offered in the sciences is forty-four (44). The number of teachers employed to give instruction in Latin and Greek fifteen years ago was four; last year the number was four; fifteen years ago the number of teachers in the sciences was five, last year the number was twenty-four.

4. The means of illustration in the classical courses have remained almost stationary; while the appliances for the pursuit of scientific studies have spread out in every direction. The physical laboratory affords constant occupation to a considerable number of original investigators. The botanical laboratory is daily occupied by a crowd of students pursuing advanced microscopical researches. The physiological laboratory is positively overrun with students from the beginning to the end of the year. The chemical laboratory last year offered to our students a hundred and seventy-five tables for personal experimentation in applied chemistry, but the number was so inadequate to a supply of the demand that the building at the present moment is in process of enlargement by nearly as many tables more. If you were to wander through these busy rooms, and see the hundreds of students clad in their scientific aprons and carrying on their researches with scalpel and microscope and test-tubes you would not fail to reform your opinion that the "whole weight of the University influence" is devoted to the encouragement of the classical course. Other universities have reared grander dormitories and memorial halls; but, if any other institution in the country has done more for the direct encouragement of scientific study and research within the past fifteen years than the University of Michigan, I have yet to learn which one it is. If you will point us to a better record than that indicated in the above facts, we will then endeavor to emulate our superior.

As your facts were at fault, of course it is not necessary to point out the error of your conclusion. I trust that the facts given are sufficient to justify you in modifying your intimation that the institution "deserves to be suppressed as a public nuisance."

I ought perhaps to correct one or two further errors of your article. But I content myself with saying that the University has *not* been "maintained from the first by public taxes"; that it was not until after it had already acquired strength, and renown even, that the first dollar of taxes was levied in its behalf; nay, that the first taxes were not levied for it until long after a fundamental law had been passed prohibiting the requiring of Latin and Greek as a condition for admission to the full privileges of the University.

You conclude your paper by comparing the University of Michigan with Cornell, and pointing to the difference, as evinced in the

contrast between Bishop Harris's address and the thesis of a Cornell student on the sanitary condition of Ithaca. I conclude mine by saying that, if you will favor the University of Michigan with a visit, the Librarian, I doubt not, will take great pleasure in showing you a cartload of theses of the very kind you so justly admire.

Very respectfully yours,

C. K. Adams.

University of Michigan,
Ann Arbor, *September* 15, 1880.

EDITOR'S TABLE.

POLITICAL SCIENCE.

WE commence this month the publication of an important series of articles on "The Development of Political Institutions" from the highest living authority on the subject of the science of society. By the science of society is meant such a systematic exposition of the facts and relations of social phenomena as shall bring out the natural laws of social change and transformation. The doctrine of evolution compels the study of society from a scientific point of view. Based upon the dynamical view of nature, the principle of continuity, and the immutable operation of cause and effect, it brings out the natural laws by which the course of society is governed in all its stages of progress and decline. The political element in society is but a part—though an important part—of a great complex organism, but it has had its laws of growth like all other parts of the organization. But, if such determinable laws of political change exist, it is desirable that they should be traced out and formulated. The discussion, therefore, now entered upon, we need hardly say, is of great theoretical and practical moment, because a knowledge of the principles by which political institutions originated and have grown up and are still advancing must become in future the basis of all intelligent political action. Social science thus elucidated will yet constitute the true foundation of the art of politics, or the practical carrying on of governmental operations; though there is as yet in the public mind but little preparation for this mode of regarding social questions. Familiar as we are with the highly developed results of long social unfolding, it is not easy to go back into the dim obscurities of social embryology. This, however, is indispensable if we are to gain any adequate understanding of the method of social development. Mr. Spencer has elsewhere dealt very fully with the impediments to the study of social evolution, and in the preliminary paper herewith printed he calls attention to some of the difficulties to be met in the political study of evolution. It is always very hard work for the loose and careless thinker to subject himself to the rigorous requirements of thorough scientific study; but the task becomes still more serious when to lax habits of thinking there are added those prejudices and gross errors to which men so passionately cling in the sphere of political thought. Yet these obstacles will be overcome as people are slowly educated to a better appreciation of the scientific spirit and the scientific method.

It is desirable to explain that the articles on "The Development of Political Institutions" that are to appear in the "Monthly" when collected will constitute that portion of Spencer's "Principles of Sociology" which is to be devoted to the evolution of political government. The preceding division on the development of "Ceremonial Institutions" is already published; and the part now appearing on political institutions will be followed by the corresponding treatment of ecclesiastical and industrial organizations. These together will form the second volume of the "Principles of Sociology," the seventh volume of Spencer's philosophical

system. We refer to this because there is much misunderstanding of the bearings of Spencer's various books on the subject of sociology. Dr. Porter, for example, has lately taken him up in the "Princeton Review," and we think, if he had been a little more particular in his reference to Spencer's sociological works, he would have given increased help to readers unacquainted with them. He says: "Spencer's contributions to this science are professedly only introductory to its study. They are to consist of 'The Principles of Sociology,' in two volumes, 'Social Statics' and 'The Study of Sociology,' as also several volumes of 'Descriptive Sociology.'" More precisely "The Principles of Sociology" will comprise three volumes instead of two. "Social Statics" is an old book, that forms no part of his sociological system, and only "The Study of Sociology," an incidental contribution to the subject, should be especially characterized as introductory to it. It is hardly fair to an author to mix up his works in this careless way, and it is especially unfair to Spencer, because he has been long engaged in developing his ideas in various lines of work, and publishing them in fragmentary parts, so that readers are easily liable to become confused in regard to them. President Porter's critical essay is entitled "Spencer's Theory of Sociology," and he says, "The only practicable method of discovering the author's theory is to subject the volume to a minute criticism." We think the still more "practicable" method would be an examination of the works in which the theory is professedly expounded rather than in a volume which disavows all attempt to formulate the principles of the science. He has explained in the preface to the work that "The Study of Sociology" was a side discussion, forming no part of the systematic treatment of social science. It was written with main reference to those prepossessions of the public mind which tend to hinder a scientific study of social subjects. Instead of explaining the science of society, the book was designed to remove objections to its possibility and to arouse interest in its legitimate questions. Yet Dr. Porter undertakes to judge Spencer's "Theory of Sociology" by an analysis of this book which does not contain it. Spencer's works are tempting game for sensational criticism, because of their extent, incompleteness, and comprehensive method, which make misconception easy and misrepresentation easier, and for this reason we are called upon to correct false impressions more frequently than would be otherwise necessary.

SCIENCE IN THE COLLEGES.

We call attention to the correspondence from Princeton and Ann Arbor correcting alleged errors in our September article on "Sewage in College Education." Dr. McCosh thinks it palpably illogical to argue that they have had typhoid fever because they do not teach physiology to the students. Our strictures were based on an assumed state of facts which is not contradicted, viz., that the fatal fever resulted from causes that were clearly preventable. We simply charged that the knowledge that would have averted the catastrophe, and which, as tending to self-preservation, is the most important of all knowledge, is culpably neglected in the college, is subordinated to more worthless studies, and not so taught as to yield the beneficent results which it is capable of producing. And what are the facts? Dr. McCosh says that the chemical professor reports as follows: "All students of the college have a full course of instruction in the outlines of human anatomy and physiology, with so much of hygiene as there is time for; and this has been done in the college for nearly half a century." That is, they teach as much about the laws of life as the old crowded classical curriculum

will allow "time" for, and hygiene is treated just as it has been these fifty years. We only say, let the knowledge that conduces to self-preservation be taught first and thoroughly, and, if the text-books are inadequate or the teachers incompetent, turn them all out together and procure those that are better.

Professor Adams, we are happy to say, makes an excellent showing of the extent of scientific study in Michigan University. But it seems we were at fault in trusting the statements of Bishop Harris, who misrepresented some things and was ignorant of others, while the plaudits which he evolved were intended rather for his rhetoric than his ideas. Professor Adams intimates that it was unfair to assume that the Bishop spoke as the representative of the university. But when a State Bishop is brought out before a State institution on an important occasion, and the customary exercises are suspended in his behalf, and he takes up the work of the institution as his theme, certainly it would not have been admissible in outsiders to question his representation of facts. Professor Adams gives an interesting and most encouraging account of the progress of scientific study in the university, and we all owe thanks to the Bishop for starting a discussion that has brought out these excellent results, and in which his inaccuracies have been overruled for good. But we will try to be more discriminating in future as to whose statements are to be trusted.

THE AMERICAN INSTITUTE FAIR.

Industrial exhibitions now seem to have become a recognized part of the machinery of trade. Those of a merely local character are held in great numbers and at many different points, while those of international range are of such frequent occurrence as to be fast losing their novelty. Most of the considerable cities of this country now have permanent organizations devoted to the giving of periodic fairs, while States and counties vie with one another in the same sort of work. The holding of fairs is a very old practice in all civilized countries; and it has always been made tributary to social gratification as well as to commercial utility. Such exhibitions are primarily a means of giving publicity to the wares of manufacturers and traders, but they are not without a further value to the general public. There must of necessity be a good deal of repetition at the successive collections, but the rapid advances now made in the arts insure the bringing forward of a sufficient number of new and interesting objects to give novelty and pleasure to the recurring displays. Great fairs are, moreover, always instructive. They not only offer favorable opportunities for observing and comparing many articles with which people desire to supply themselves, but, by bringing together the best products of useful and artistic workmanship, they familiarize the public with the highest standards of excellence, and become the centers of impulse, and incite to still further improvement. International exhibitions have undoubtedly had great effect in stimulating whole communities to apply greater intelligence to the processes of the arts and to attain a higher perfection in industrial products; and this wholesome education has been also promoted, though in a lesser degree, by the large local exhibitions.

Among the fairs annually held, those of the American Institute have long had a leading place. The position of the Institute, at the chief distributing point of the country and the center of population, has doubtless contributed largely to give its fairs such a character; but the judicious conduct of the concerns of the society and the discretion with which awards have in the main been bestowed have been no less important factors. The American Institute was the pioneer in the work to which it is devoted—the promotion and

encouragement of the industrial arts in this country. Founded in 1828, it has for half a century had a successful career. Its growth has been coincident with a most remarkable industrial development, and its exhibitions during this period have been among the most available means of bringing to the early notice of the public the most important and valuable inventions and improvements of which this country has been, perhaps, more prolific than any other.

The forty-ninth exhibition is now being held, and in point of variety and interest of exhibits compares favorably with those of preceding years. No remarkable machines or processes are shown, but in several departments there are appliances which are decided advances upon previous constructions. As a whole, the exhibition is well worth a visit, and there is much to be seen there that will repay careful examination.

POWDER AND BALL FOR DEMAGOGUES.

President Hayes has been discussing the subject of public education; and, in his speech at Canton, Ohio, he called attention to the extent, and pointed out the main sources, of illiteracy among our heterogeneous populations. Ten years ago, he says, there were three quarters of a million of negro voters who could not read their ballots, and in this respect things have not improved much since. The Indian tribes which we must soon absorb are equally ignorant. Half the population of New Mexico can not read and write, and, of the enormous immigration from Europe, from twenty to twenty-five per cent. are to the same degree illiterate. Mr. Hayes maintains that it is the duty of the national Government to enter upon the great work of public education with the view of qualifying all these incompetent citizens, present and prospective, for the proper exercise of the right of suffrage.

In referring to these various classes of persons, Mr. Hayes uses the terms "illiteracy," "ignorance," and "unable to read and write" interchangeably or as equivalents; that is, the "ignorance" of which he speaks seems to be that grade of incapacity or illiterateness which is indicated by inability to read and write. We are left to infer that this is the ignorance which he considers dangerous to the state, and which it is therefore the duty of the national Government to remove. We assume that this is the sort of ignorance which Mr. Hayes means when he says, "In our own country, as everywhere else, it will be found that in the long run ignorant voters are powder and ball for demagogues."

Are we to conclude, then, that in the belief of President Hayes, if the negroes, Indians, immigrants, and illiterate people generally are taught to read and write, American demagogues will be deprived of their ammunition, and republican government placed upon an enduring foundation? Does Mr. Hayes think that the real danger to popular institutions in this country comes from the presence of those who are unable to read their ballots? Certainly the most dangerous class in the community is the demagogues themselves, and these can not only read and write, but they are commonly educated men. Nor is this all; they are the dangerous enemies of republican institutions by virtue of that education which gives them command of the means of mischief. And as it is by education that they are qualified for the skillful practice of their vicious arts, so it will be found that a certain amount of education on the part of their victims is necessary to bring them within the full range of demagogical influence. It is not the illiterate classes by any means that are most misled and cheated by the demagogues. It is those who can read the newspapers and campaign documents that are most openly accessible to the flatteries, de-

ceptions, and cunning artifices of wily political managers. The illiterate classes are indeed, to no small degree, protected by their very ignorance from the most insidious forms of political imposture. They are manipulated by coarse methods, while the class of citizens who are called intelligent, morally require sharper practice to circumvent them. It is a great mistake to suppose that our demagogues are mere petty operators, animated by low cunning, and who find their chief prey among those who can not read their ballots. They are trained and accomplished men, subtle of intellect, inventive in resources, and well equipped with knowledge. The great mass of the people have a smattering of education, and the whole system of demagogical art assumes it and is adapted to it. The common schools teach just enough to turn out "powder and ball for demagogues." Our "machine politics" is the bright consummate flower of American demagogism, but it never could have had so vigorous a growth if the ignorance of American voters had not been duly cultivated. The more ignorant and stupid men are, the greater is their fealty to party, and the more easily they can be counted on; but, as they begin to think, the demagogue is thrown upon his resources, so that the effect of the schools is to cause him to perfect his methods. Of course, ignorant voters are everywhere "powder and ball for demagogues"; we only insist that there shall be no demagogical narrowness in defining the class of ignorant voters.

LITERARY NOTICES.

Two Worlds are Ours. By Rev. Hugh Macmillan, LL.D., F. R. S. E. New York: Macmillan & Co. Pp. 349. Price, $1.75.

To say that this book is by the author of "Bible Teachings in Nature" and "First Forms of Vegetation," published several years ago, will be a strong commendation to many readers. Those books were full of a peculiar interest derived from their author's special studies; and the present work, similar in character, well sustains the writer's reputation. Dr. Macmillan combines, in a somewhat marked degree, several traits which give character to his productions. He is first of all a devoutly religious man, of strictly orthodox opinions, and profoundly impressed with the reality of the spiritual world; and he writes to illustrate and enforce the fundamental conceptions of the Christian system. Then he is an enthusiastic student of nature, and well up in the latest results of science—especially in geology, botany, and zoölogy, the objects of which are so obtrusive in all the aspects of nature. He is besides a clear and pleasing writer, with a dash of poetic feeling which gives life and vividness to his descriptions, though sometimes betraying him into undue fervor and elaboration of style Though his book is pervaded by the most literal orthodox beliefs stated in Scripture forms, yet it is in no sense a polemic, nor is there any attempt to establish his theological views by the customary logical methods. He rather aims to enforce their truth by showing in what striking ways they harmonize with the methods and operations of nature. His virtual thesis is that the "Two Worlds," spiritual and material, are ever in agreement when we get down to their deeper meanings, and he gives many ingenious and interesting exemplifications of this unity. The book is written in excellent temper, and is free from all asperity. Science is looked upon, not as the enemy but as the handmaid of faith; and, although advanced views are accepted as a matter of course, there is never a word of disparagement of scientific men. The moral inculcations of the volume are elevated and impressive, and, with their fresh and attractive illustrations, can not fail to exert a wholesome and improving influence. Of its twenty-one chapters, those entitled "Grains of Sand," "Weeds," "Summer Blossoms," "Mountain Peace," "Leaven," "Snow," "Waste," and "The Days of a Tree," have most interested us.

A True Republic. By Albert Stickney. New York: Harper & Brothers, 1879. Pp. 271. Price, $1.

Mr. Stickney here grapples with the problem of the causes and the cure of the

widespread and increasing demoralization in American political life, and, where others who have as keenly felt the evil have contented themselves with vague utterances, he proposes a definite scheme of action. The impatience with party methods and party dictation, which is now so evident among thinking men, has not generally gone to the length of questioning the utility or necessity of such organizations. Parties are held, by even those most energetic in their opposition to their present tendencies and methods, to have a legitimate function in a free state. It is only their abuse that there is need to war against. Rightly limited, they are the sole means of giving effective expression to the popular will, and for carrying out lines of national policy. Emancipated from the control of the self seeking classes, they are the most efficient agents of the control of the affairs of government by the people, and the problem of our politics is to get their management into proper hands. This opinion Mr. Stickney denies outright. Parties, in the sense of vast permanent organizations, are to him wholly an abomination. They do not now aid, and never have aided, in furthering calm political discussion, or in carrying measures of real value to the people. They are now, and always have been, organizations for the carrying of elections. The great questions of the hour have indeed been used by them as their battle-cries, but the contest has always been for the places of honor and profit. They have pushed these questions to issue only to the extent demanded by their needs; the real interests of the people have always been made subservient to their triumph. Wise legislation is the outcome of deliberation, of a careful consideration of the real merits of the questions involved. It needs honesty of purpose and harmony of spirit. But the very essence of party is strife. Warring factions, jealous of any possible advantage that one side may gain over another, perpetually prevent all harmony of action between those holding by different parties. The action of legislators, elected to conserve the interests of the whole people, is determined almost solely by party considerations. The division of votes on most questions is along strictly party lines. As a means of affording discussion of the merits of the men and measures presented for popular suffrage, they are worse than useless. The candidates are all chosen by the managers, and the people have only the choice of ratifying at the polls the selections of the caucus. These are not accidental but inherent features of the party system. They are bad enough, but they are but a part of the evils due to it. The feature that makes improvement hopeless, and that paralyzes all attempts to reform within party lines, is the influence that the system inevitably exerts over our public men. In it is to be found the cause of the progressive corruption of public servants. Not only does it offer the opportunity for public servants to do their work ill, but, more than that, it compels them to do it so. Their continuance in office is dependent upon their party carrying the next election. They are therefore forced to devote their time and energies to keeping their places. They can not, therefore, give their attention to the proper work of their offices. More than this, they must of necessity administer these offices, not with an eye to the public good, but to the best advantage of their party. The system, therefore, makes it certain that the public will neither get good service from the men in office, nor get the best men to do Government work. These results are not peculiar to America. They have followed wherever tenure of office has been made to depend, not upon the faithful performance of duties, but upon political success. Men will always, at all times and places, give their best work to that upon which their preferment depends. If in this country party control has gone to greater lengths than in other countries, and not only the elective, but all offices, have come to be the prey of party faction, it is because the opportunities have been greater. Our frequent elections make possible the profession of the politician. Every few years a chance of a change in party control of the Government gives a promise of vacancy in great numbers of offices. Men, therefore, temporarily out of office can wait for one of these recurring opportunities. Mr. Stickney reviews English and American history in support of his position. He finds that security of tenure and official purity have

been invariably associated, while corruption and tenure dependent upon political success have always gone along together.

Sweeping as is the indictment of party, its methods and results, its substantial accuracy will be questioned by few conversant with the facts. The evil is allowed, but the means of remedying it are not clear. To many it has seemed that there is no cure. Mr. Stickney is not of this number. His showing of the causes upon which the evil depends has revealed to him the method of eliminating it. The public does not get its best men in the public employ, or get from its servants their best work, because the best men will not condescend to the work necessary to enter and remain in the public service, and because they have not security in their position during "good behavior." In the callings of private life men have the assurance that, if they do their work well, they will have employment for life. They have also the assurance that, if they do it ill, they will lose their employment. They are therefore under constant pressure to do their work well. Mr. Stickney believes that these conditions can be realized in the public service by the changes in our political system which he advocates. These changes consist in abolishing the term system, in so arranging the control of appointment and dismissal from office that there shall be direct responsibility for the performance of the work of the various departments, and in reducing the number of elective offices to the lowest point. To this end the President is elected as now, not for any definite term, but to continue in office so long as he performs his duties well. He has absolute control over the appointment and dismissal of the heads of departments. These heads have in turn the same power over their subordinates, and are responsible to the Chief Executive alone for the work of their departments. And so down through the entire service, each employee being responsible to his immediate superior for the faithful performance of his duties, and being assured of his place only so long as they are well done. To secure efficiency, each man must have work of only one kind. The Chief Executive is given no voice, as now, in legislation, his veto-power being taken from him. He is responsible for the work of the entire Executive branch of the Government to the National Assembly. Mr. Stickney favors only one body, of four or five hundred men, instead of the two we now have; but, if there be two, it is sitting as one body that they form the Assembly to whom the Executive is responsible. The Executive may be at any time removed for any cause by a two-thirds vote of this Assembly. The Assembly has no voice in the choice of a new Executive. The senior department officer is made President *pro tem.* pending the election of a new President. The members of the Legislature are elected, like the President, for no definite term. They can be turned out of office by a two-thirds vote of the Assembly of which they are members. The judges are also made elective, but for no definite time. These are the only elective offices, in the national, State, and city governments. All the others are by appointment. Under this system the power of party as now existing would be destroyed, Mr. Stickney holds, because there would be few offices to be captured by election work, and, the tenure being dependent upon good behavior, it would be impossible to determine when these few would be vacant. The office-seeker would then disappear, because the profession could no longer pay. And the office-seeker as a distinct class having disappeared, public servants would become as efficient and as honest as those in private life. The whole of Mr. Stickney's scheme turns upon this point—the breaking up of party organization by removing the opportunities of profit which keep it intact.

It seems to us that it is just here that the scheme fails. The power of party managers is dependent not upon themselves alone, but upon the following they can command. And they can command this following in virtue of the intensity of party feeling. It is because there are multitudes of men who can be rallied by the party cry to support it through thick and thin that the managers are able to prostitute the services of the Government to their own ends. The diminishing of the elective offices not only would not reduce this partisan feeling, but would have no tendency to do so. These elective offices are, moreover, but a part of those of the Government. The

great mass of those which are now filled by appointment—and which, under Mr. Stickney's system, would be increased—are as much sought after by party workers as those that are elective; and there is no greater security under the proposed system than under the present, that they will be kept out of their hands. The security is even less, because the Executive has greater power. Suppose the chief Executive and the required majority of the Legislature to be of the same party, with the same intense partisan feeling existing that now exists, what, under Mr. Stickney's system, is to prevent the offices from the top to the bottom being filled with political workers, and kept there without any more regard for their fitness than at present. A majority gained by the other side would simply have the effect of putting in a new Executive, who might make a clean sweep of the departments in the interest of his party. The only restraining force upon him then, as now, would be the pressure of public opinion, but that would necessarily be less than at present, because it could not make itself so effectively felt. The same party majority that would be able to keep the Executive in power for party reasons would also be able to keep members of the Legislature of their own party in their seats. Practically a member would be secure in his tenure unless guilty of the grossest misconduct. And party standards of conduct are not of the highest. If this Assembly were composed, as Mr. Stickney supposes, of the best and wisest men of the nation, and the chief Executive were a man of great administrative ability and honesty of purpose, doubtless his plan would work admirably. But a system must be judged by its ability to meet the worst cases. If the Assembly were filled with strong partisans, and the Executive were the willing tool of his party, the result would be anything but satisfactory, and there would be, under the law, no means of effecting a change. While the discussion of Mr. Stickney is in many ways suggestive, and throughout bears the evidence of careful thought, his system can not, to our thinking, be accepted as a solution of the problem. Without a destruction of the party spirit, it affords no better security for efficient and faithful service than the present one, and, with the destruction of this spirit, its purpose can be accomplished with the system we have.

An Elementary Text-Book of Botany. Translated from the German by Dr. K. Prantl, Professor of Botany in the Royal Academy of Forestry, Aschaffenburg, Bavaria. The Translation revised by S. H. Vines, Fellow and Lecturer of Christ's College, Cambridge. With 275 Illustrations. Philadelphia: J. B. Lippincott & Co. 1880. Price, $2.25.

In his preface to the English translation of Professor Prantl's text-book, Professor Vines tells us that the work appeared in Germany in response to a demand for an introduction to Professor Sachs's well-known and voluminous "Lehrbuch der Botanik," that should resemble it in its mode of treating the subject. Professor Prantl's success in this undertaking is attested by the rapidity with which his book has passed to a third edition in his own country, and by its prompt translation into English. The large work of Professor Sachs was translated by Bennet and Dyer, and published at Oxford in 1875. To readers unacquainted with this important volume, we may say that it introduces the student to the present state of knowledge concerning botanical science. It not only describes the phenomena of plant-life that are already accurately known, but it indicates those theories and problems in which botanical research is at present engaged. It is a quarto volume of 860 pages, of which some 200 are given to the consideration of "General Morphology," nearly 400 to "Special Morphology and Classification," about 200 to "Physiology," and the remaining 60 or 70 pages to chapters on "Plant Movements," "Sexual Reproduction," and "The Origin of Species." Professor Prantl's introduction to Sachs's "Botany" is an octavo volume of 332 pages. In treating a subject of such great extent in this brief space, the author has adopted a somewhat different order from that of the large work, and omitted many of the recondite subjects which are there so ably presented. The introductory chapter is devoted to external morphology. The anatomy of plants is treated in two chapters, the first upon cell-structure, contents, and development; and the second

upon tissues. "Plant Physiology" is treated in six chapters, and the remainder of the volume, over two hundred pages, is devoted to the "Classification of Plants." Special morphology is here elucidated, along with the exposition of the characters which underlie classification. The illustrations are numerous, attractive, and very helpful to an understanding of the text.

As a brief exposition of the complete science of botany, we have seen nothing equal to this manual, which is every way worthy of the incomparable work to which it is the stepping-stone.

Contributions to the Archæology of Missouri by the Archæological Section of the St. Louis Academy of Science. Part I, Pottery. Salem, Mass.: George A. Bates. $3.00.

This handsome quarto volume is printed on heavy tinted paper, and is illustrated by five folded maps and twenty-four lithographic plates, containing one hundred and forty-eight figures. It contains a description of the earthworks and brief references to the archæological remains of southeastern Missouri, by Professor W. B. Potter, and a description of the ancient pottery by Dr. Edward Evers. Their descriptions are terse and to the point. Dr. Evers has no theory regarding the race of people who made this pottery, neither does he permit himself to see some symbolic conception in every quaint design he meets with. He gives precisely what his readers want, a profusely illustrated volume of one hundred and forty-eight figures of various vessels, strongly drawn, and well drawn too.

We congratulate the St. Louis Academy of Science on this evidence of its prosperity, and we particularly congratulate its Archæological Section that it wastes no time or money in rummaging through Greece, Cyprus, or other parts of the Old World, in quest of antiques, when at home such rich treasures are to be revealed.

Life on the Seashore; or, Animals of our Coasts and Bays. With many Illustrations. By James H. Emerton. Salem, Mass.: George A. Bates. $1.50.

This little book forms the first volume of the "Naturalist's Handy Series," and is alike creditable to author and publisher. It will be found an exceedingly handy book for any one interested in the animals of the coast of New England. Much information regarding the development and habits of the lower animals is here given in a clear and concise form.

As a successful zoölogical draughtsman, Mr. Emerton should remember that an object expressed in lines is to be acknowledged as fully as an idea expressed in words. This remark is necessitated by his neglect in many cases to give the authorities for the drawings he uses. The book is handsomely bound and printed.

Introduction to the Mortuary Customs among the North American Indians. By Dr. H. C. Yarrow. Washington: Government Printing-Office. 1880. Pp. 107.

The series of works, of which this volume forms the third installment, has been undertaken with the object of obtaining a complete and trustworthy account of the present and ancient customs and beliefs of our North American Indians. Though much has been written on the subject by travelers and explorers, the amount which is of value is comparatively small, through carelessness of observation and the predispositions of the writers. The volumes only profess to be introductions, but it is hoped that, by awakening the interest and directing the attention of those in a position to obtain first-hand knowledge, a body of accurate and, in time, comparatively complete information can be obtained. Introductions to the study of Indian language and Sign-language, the first by Major J. W. Powell, and the latter by Colonel Garrick Mallery, have already appeared. The present volume will be followed by similar ones upon the medicine practice, the mythology, and the sociology of these Indians. In the preparation of the volume on mortuary customs, Dr. Yarrow has enlisted the services of a great number of observers, with the result of obtaining a large mass of reliable data. The plan adopted was to send to Indian agents, physicians resident at agencies, army officers, and others, a circular clearly setting forth the kind of information desired, and the precautions necessary to be taken to get it reliable. The ground covered by the volume includes the care of the lifeless body

previous to burial, and the ceremonies attendant upon it; the method of burial, the site, attitude of body, its manner of resting, the ceremonies and the beliefs of the tribe where it occurs concerning it; the gifts offered to the dead, at the time of burial and later; the superstitions relative to the influence of the dead over the living; and all those practices which express these beliefs, as well as the methods and periods of mourning. Many of the customs and practices described are extremely curious, and all are of interest, not alone to one whose studies have been in this field, but to all intelligent people. The coöperation of all who have opportunities of observation of the Indians is solicited, to the end of making the final publication on the subject as complete and valuable as possible.

Annals of the Astronomical Observatory of Harvard College. By Edward C. Pickering, aided by Arthur Searle and Winslow Upton. Vol. II, Part II. Photometric Observations. Cambridge, University Press: John Wilson & Son. 1879. Pp. 315.

This is a continuation of the photometric observations of Professor Pickering upon the light of the stars. The observations include those upon the satellites of Mars, Jupiter, Saturn, Uranus, and Neptune. Measurements have also been made of the light of unequal double stars, where the difference between the two is considerable, and also of that of a number of the asteroids. Some observations upon the limit of visibility have also been made, and are still in progress. A discussion of the results obtained on this latter subject is reserved for a future part.

The Hair, its Growth, Care, Diseases, and Treatment. By C. Henri Leonard, M. A., M. D., Professor of Medical and Surgical Diseases of Women in the Michigan College of Medicine. Illustrated by 116 Engravings. Detroit: C. Henri Leonard. Pp. 319. Price, $2.

The author has here evidently aimed to make a popular work, conveying as much scientific information as he can make consistent with that idea. It seems to be a very good digest of general knowledge relating to the structure and diseases of the hair, and gives many hints respecting its care and healthful preservation. The volume is interspersed with a great deal of curious information respecting extraordinary hair-growths, and the author is fond of applying the multiplication-table to the subject, and bringing out the most astonishing results from insignificant elements. For example: "Were it possible to place end to end the hirsute covering of the heads of Detroit citizens, we would have a hair-line long enough to more than reach thirteen times to the moon, or one that would belt the earth some one hundred and twenty times at its equator." The volume is preparatory to a larger work, in which the author promises to show the possibility of the classification of animals from the differences in the microscopical structure of their hair-shafts.

Essays on Art and Archæology. By Charles Thomas Newton, C. B., Ph. D., D. C. L., LL. D. London: Macmillan & Co. 1880. Pp. 472. Price, $4.

In this volume Mr. Newton has collected a number of papers contributed by him to different periodicals, most of them in recent years, though several date back a considerable time. They are written in an agreeable style, and will be found of interest, not only to those who have more or less acquaintance with the subject, but to the wider circle of the general public.

The opening paper of the volume, read at the Oxford meeting of the Archæological Institute, in 1850, is an exposition of the scope of the science, bearing the title "On the Study of Archæology." In it the author considers the kind of records of the past of the human race with which archæology is concerned, the difficulties that encompass investigation, and the need of museums, etc., where the collections of materials can be classified and disposed for intelligent study. Mr. Newton's experience, as keeper of Greek and Roman antiquities in the British Museum, qualifies him for the discussion of the best way of arranging the collections in that institution, which forms the second paper of the volume. That placed third is devoted to an account of the Greek sculptures from the west coast of Asia Minor, now in the same museum. A long and interesting essay is that on "Greek Inscriptions," in which Mr. Newton points out the great

mass of this material at the disposal of the archæologist, and refers in detail to many of the more important inscriptions. Mr. Wood's discovery of the site, and his restoration of the temple at Ephesus, which, in the time of St. Paul, was one of the seven wonders of the world, Mr. Newton presents in his article on "Discoveries at Ephesus," and the discoveries of Dr. Schliemann at Mycenæ in the one following. "Researches in Cyprus," "Discoveries at Olympia," "Greek Art in the Kimmerian Bosporos," and "Greek Numismatics," complete the papers of the volume. A Greek inscription, engraved on the four sides of a *stelè* of blue marble, which was some years since discovered in the Castle of St. Peter, at Budrum, is reproduced in an appendix.

Qualitative Chemical Analysis. By Silas H. Douglass, M. A., M. D., and Albert B. Prescott, M. D., F. C. S. Third edition, wholly revised. With a Study of Oxidation and Reduction, by Otis Coe Johnson. New York: D. Van Nostrand. 1880. Pp. 305.

The new feature in this edition of this excellent manual is the text upon oxidation and reduction, by Mr. Otis C. Johnson, in which a new interpretation is given to quantivalence. The authors state that the method of Mr. Johnson has proved very successful in teaching, and bespeak for it a careful examination by chemists. The subject is technical, and can be fully understood only by those acquainted with chemical theory and manipulation. Besides the addition of this new matter, the book has been carefully revised, and such improvements made as the experience of actual use in teaching has suggested.

Some Thoughts concerning Education. By John Locke. With Introduction and Notes by Rev. R. H. Quick, M. A. Cambridge, Eng.: University Press. 1880. Pp. 240. Price, 90 cents.

Although put forth so long ago, the "Thoughts" still possess a value for the modern student of education. Locke's ideas of the purpose and scope of education were greatly in advance of the practice of his own time and of much of that of ours. He recognizes that education is properly a developing of the natural powers, and not a mere loading down the memory with undigested knowledge. Many of his suggestions and recommendations are so entirely in agreement with modern views as to seem commonplace. His advice in the matter of physical education is especially noticeable for its concordance with present medical practice. Dr. J. F. Payne, who contributes valuable notes upon the medical portions of Locke's discourse, finds little to correct in his recommendations, except those advising that children's feet be wet, and they be otherwise exposed, to harden them. Besides the treatise of Locke, the book contains a biographical sketch of him, and a critical estimate of his services in education, and his relation to his predecessor in educational reform, Montaigne, and his successor Rousseau. His plan of working-schools for the children of the poor and his essay "Of Study" form an appendix, while the notes of Dr. Payne, mentioned above, with others not so good, and an index, complete the volume.

The New Text-Book of Physics. An Elementary Course in Natural Philosophy, designed for Use in High Schools and Academies. By Le Roy C. Cooley, Ph. D. New York: Charles Scribner's Sons. 1880. Pp. 317.

Professor Cooley was among the first to attempt to introduce into elementary instruction in physics the modern doctrine of molecules and molecular action. In his text-book of natural philosophy, published some twelve years ago, he sought to give it a form suited to the comprehension of the class of students for whom the book was designed. In this revision of the former work he has aimed to do the same thing for the fundamental conception of the science—that of energy. Heat, light, etc., are accordingly presented as so many different manifestations of energy, and not as a number of distinct forces. The work is arranged to bring out the essential features of the conception, and then to show its applications in explanation of the various groups of phenomena within the scope of physics. The first three chapters are devoted to a gaining of clear ideas of the properties of matter and laws of motion. These lead up to the doctrine of energy, which is explained and illustrated in the

fourth. In the four succeeding chapters, the forms of energy constituting heat, light, sound, and electricity are considered, with such illustrative examples as exhibit the essential features of each group. A brief summary of the principles of machines forms the closing chapter. A new feature of the book is a review at the end of each chapter, consisting of principles and topics, and a number of problems. Simple restatement of principles in the order of the previous discussion has been avoided, with the object of showing the truths enunciated in new relations and with added force. The text throughout is fully illustrated.

Eminent Israelites of the Nineteenth Century. By Henry Samuel Morais. Philadelphia: Edward Stern & Co. 1880. Pp. 371. Price, $2.

The careers of the hundred Jews, whose portraits Mr. Morais has presented in this volume, speak much for the inherent vitality and power of a race so long proscribed. The sketches are brief, much too brief to do justice to many of their subjects, but they are in the main judicious and are full of interest. The labors of these eminent Hebrews take a wide range. Literature, theology, music, philanthropy, statesmanship, and commercial pursuits all have their representatives, many of whom have achieved not only distinction, but positions of the very first rank. They are as diverse in their nationalities as in the character of their labors, coming as they do from all European states, as well as from America. The record as a whole is one with which Jews have reason to be gratified, while it is interesting and instructive to a wider circle.

Manual of Hydraulic Mining, for the Use of the Practical Miner. By T. F. Van Wagenen, E. M. New York: D. Van Nostrand. 1880. Pp. 93.

Placer-mining, the author states, is, when economically conducted, as certain of good returns as any ordinary avocation. Auriferous gravel deposits are very extensive on the Pacific coast, and, as the plant necessary is comparatively inexpensive, the miner has a wide field for remunerative work. He must, however, conduct his operations with a knowledge of the nature of his materials and the most efficient way of working them to secure success. Most miners at present engaged in hydraulic mining, Mr. Van Wagenen says, have but slight knowledge of physics, and are more or less rusty in their arithmetic, so that many errors are made in construction and operation, which prove costly experiments. He has therefore attempted, in this little manual, to give, in a clear and concise form, the information needed to avoid such errors. Among the subjects briefly treated are the use of decimals; the methods of finding areas and volumes; the pressure of water when at rest, and its flow through orifices and flumes; the proper method of constructing flumes, their grades, size of nozzles, etc. Tables of square and fifth roots of the numbers commonly entering into the miner's calculations are given at the end of the book.

Deep-Sea Sounding and Dredging. A Description and Discussion of the Methods and Appliances used on board the Coast and Geodetic Survey Steamer Blake. By Charles D. Sigsbee, Lieutenant-Commander U. S. Navy. Washington: Government Printing-Office. 1880. Pp. 208.

Lieutenant-Commander Sigsbee was in charge of the Blake for the four years from December, 1874, and during this time prosecuted extensive researches relative to the condition of the deep-sea bottom. During the winter of 1874-'75 soundings were made off the mouth of the Mississippi River, the total number of miles being 2,505. Nearly as many miles of soundings were taken in the Gulf of Mexico in the summer of 1875, and in the winter of that and the next year a system of east and west lines was run across the great bank west of the Florida Peninsula. Others were run on the northern portion of the bank, and a number from the delta of the Mississippi out to sea, closing with a line from the South Pass to the Yucatan Bank, and one from Alacran Reef to Tortugas. The remaining years were devoted to further soundings in this portion of the waters of the American coast. The Blake was very thoroughly fitted out for her work. Her party was one of the first to use piano-forte wire for deep-sea dredging and trawling, and the experience with it showed it to be much better than

rope. The greater part of the apparatus used was either new or improved forms of that ordinarily used, and much of it was due to the ingenuity of Commander Sigsbee. The present work does not go into the results obtained by the various expeditions, but is devoted to a description of the apparatus employed and statement of its actual value in use. Detailed drawings supplement the descriptions, and a large number of heliotype plates clearly show the arrangement and method of using on board ship.

PUBLICATIONS RECEIVED.

Circulars of Information of the Bureau of Education. No. 3. Legal Rights of Children. Washington: Government Printing-Office. 1880. Pp. 96.

Address before the American Association for the Advancement of Science, Section A. By Asaph Hall. Boston Meeting, August 25, 1880. Cambridge: John Wilson & Son. Pp. 16.

Progress of Western Education in China and Siam. Pp. 13. The Indian School at Carlisle Barracks. Pp. 5. Vacation Colonies for Sickly School Children. Pp. 2. From the Bureau of Education. Washington: Government Printing-Office. 1880.

Water Pollution, and a Remedy for the Evils of the Present Water-Supply Systems proposed. By Nelson Green. New York: The Hub Publishing Co. Pp. 29.

Who planned the Tennessee Campaign of 1862? or, Anna Ella Carroll *vs.* Ulysses S. Grant. By Matilda Joslyn Gage. Pp. 16.

An Examination of the Double-Star Measures of the Bedford Catalogue. By S. W. Burnham, Esq. Pp. 36.

What constitutes a Discovery in Science? By Dr. George M. Beard. New York. 1880. Pp. 7.

A Reply to Criticisms on "The Problems of Insanity." By Dr. George M. Beard. 1880. Pp. 34.

Occurrence of Microscopic Crystals in the Vertebræ of the Toad. By H. Carrington Bolton. Pp. 4.

Notice of Jurassic Mammals representing Two New Orders. By Professor O. C. Marsh. Illustrated. Pp. 5.

National Association for the Protection of the Insane and the Prevention of Insanity. Boston. 1880. Pp. 31.

Bulletin of the Philosophical Society of Washington. Vol. I, 1871–'74. Pp. 49. Vol. II, 1874–'78. Pp. 392. Vol. III, 1878–'80. Pp. 169. Washington: Published by the Coöperation of the Smithsonian Institution.

Drug Attenuation: its Objects, Modes, Means, and Limits in Homœopathic Pharmacy and Posology. By the Bureau of Materia Medica, Pharmacy, and Provings in the American Institute of Homœopathy, 1879 and 1880, J. P. Dake, M. D., Chairman. Philadelphia: Sherman & Co. 1880.

Action of Light on the Soluble Iodides, with the Outlines of a New Method in Actinometry. Pp. 22. The Literature of Ozone and Peroxide of Hydrogen. Pp. 63. Laws governing the Decomposition of Equivalent Solutions of Iodides under the Influence of Actinism. Pp. 7. By Dr. Albert R. Leeds.

Memoirs of the Science Department of the University of Tokio, Japan. Vol. III, Part I. Report on the Meteorology of Tokio for the Year 2539 (1879). T. C. Mendenhall. Tokio: Government Printing-Office. 1880.

On the Algebra of Logic. By C. S. Peirce. Reprinted from the "American Journal of Mathematics." Pp. 42.

The Textile Record of America. Devoted to the Manufacture and Distribution of all Woven Fabrics: Cotton, Wool, Silk, and Flax Culture. Edited by Lorin Blodget. Philadelphia: Nagle & Ryckman. Monthly. Pp. 16. $3 a year.

An Elementary Treatise on Analytic Geometry, embracing Plane Geometry and an Introduction to Geometry of Three Dimensions. By Edward A. Bowser. New York: D. Van Nostrand. 1880. Pp. 287.

American Aristocracy. A Sketch of the Social Life and Character of the Army. By Duane Merritt Greene. Chicago: Central Publishing Co. 1880. Pp. 222. $1.

The Minor Arts. By Charles G. Leland. Illustrated. London: Macmillan & Co. 1880. Pp. 148. 90 cents.

Hints for Home Reading. A Series of Chapters on Books and their Use by Different Authors. Edited, with an Introduction, by Lyman Abbott. New York: G. P. Putnam's Sons. 1880. Pp. 152. 50 cents.

School and Industrial Hygiene. By D. F. Lincoln, M. D. Philadelphia: Presley Blakiston. 1880. Pp. 152. 75 cents.

German Thought from the Seven Years' War to Goethe's Death. By Karl Hillebrand. New York: Henry Holt & Co. 1880. Pp. 298. $1.75.

Diseases of the Throat and Nose. By Morell Mackenzie, M. D., London. Vol. I. Diseases of the Pharynx, Larynx, and Trachea. Illustrated. Philadelphia: Presley Blakiston. 1880. Pp. 570. $4.

POPULAR MISCELLANY.

Improved Safety Construction of Elevators.—With an appliance in such general use as the elevator, means of securing safety in case of the parting of the cable, or failure of other parts of the moving apparatus, are of prime importance. A great variety of devices, many of them quite ingenious, have been designed to accomplish this object, but few of them are entirely satisfactory. They have done much to decrease accidents, but these still happen frequently enough with them to show the necessity of a more perfect apparatus. These mechanical stops consist of combinations of levers, pawls, and clutches so arranged that the weight of the carriage will throw them into action. Both classes, those which bring the carriage to a sudden stop, and those which act as a break, need to begin to act the moment the fall commences, or the motion becomes so great as to be beyond control. From various causes impossible to provide against, these devices

frequently fail at the critical moment, causing loss of life or damage to property. Recently a system of protection has been perfected and is now being introduced, which, the promoters claim, secures perfect safety, and the trials made in this and other cities seem to amply confirm the claim. It consists in making the descending carriage act as a plunger to compress the air in the shaft below it, so as to form a cushion which retards and gradually overcomes its motion. The change in the ordinary construction of the elevator to secure this action is very slight, and can readily be applied to one already put up. The shaft is made to fit the elevator carriage closely, through the first three or four feet of the lower portion, and then gradually widens to the full size. This funnel-shaped portion extends from fifteen to twenty feet above the contracted base, depending upon the size and height of the elevator. A stiff rubber flange around the lower edge of the carriage leaves a space for the escape of the air in the contracted portion of not more than one fourth of an inch wide. The straight part of the shaft above the funnel is of a size to leave a space of six to eight inches all around the carriage. With such a constructed shaft, the carriage, when it begins to fall, readily presses the air from beneath it up the sides of the shaft. As it gains in velocity, greater resistance is offered by the air, and, as it descends through the funnel portion, this is rapidly increased by the narrowing of the air outlet. When the contracted base portion is reached, the confined air has only a narrow outlet, and the resistance it offers is consequently very great. The air arrests the motion of the carriage so gradually that there is very little shock. In one of the trials in this city where the fall was seventy-five feet, eggs and delicate glassware placed on the floor of the car were unbroken. A great number of trials have been made, and many persons have gone down in the falling cars without injury. With the shaft properly and strongly built in the lower portion where the strain comes, this apparatus seems to offer no chance of failure.

Types of Pottery.—Professor E. S. Morse read an interesting paper on this subject at the last meeting of the American Association. The earlier types belonging to the shell-heaps of Japan were described and illustrated by specimens from each of the deposits examined by Mr. Morse and his special students. The pottery of Yezo was nearly all cord-marked, while the shell-heap pottery of the middle of Japan had a much less proportion cord-marked. In the southern portions of Japan, at Higo, cord-marked pottery was extremely rare. He remarked on the extreme diversity in the shape and ornamentation of the pottery in different places in Japan—the pottery of Yezo resembling the pottery of the northern United States, and the pottery from the central portions of Japan resembling that found in Porto Rico and Jamaica. He also spoke of the hard, blue pottery supposed to be Corean, and associated with it a red pottery which might have been made by the same people. This was lathe-turned. Other forms were mentioned and illustrated by examples.

The Fiftieth Meeting of the British Association.—No remarkable discoveries were brought forward at the recent meeting of the British Association for the Advancement of Science, but the addresses and papers in the various sections showed a steady advance in scientific work. Professor A. C. Ramsay, the new President, chose for the subject of his inaugural address the doctrine of uniformity, under the title of "The Recurrence of Certain Phenomena in Geological Time." There has recently been a disposition in certain quarters to question the truth of the doctrine in the extended application made by most geologists. The questioners admit that geologic changes in times past were produced by the same forces now in operation, but deny that they were of the same degree. The uniformity and cataclysmic theories seem to them to both contain truth. Professor Ramsay reaffirms the uniformity doctrine in the broadest and most general manner, and very ably defends his position. One of the most valuable if not the most important address of the meeting was that of Professor W. G. Adams, before the Section of Mathematics and Physics, reviewing recent work in the domain of molecular physics. His statement of the molecular condition of the three forms of matter —solid, liquid, and gaseous—was the clear-

est and least technical that has been made. He reviewed the work done by Lockyer and others in spectrum analysis, and, without committing himself to the conclusions drawn from them by the several workers, pointed out that the advance in our knowledge of molecular action is in the direction of effacing the distinction between chemistry and physics. It seemed to him even that all the sciences were becoming more and more branches of physics—that they "are yielding results of vast importance when the methods and established principles of physics are applied to them." Professor Adams closed his address with a consideration of the influence of the sun in producing magnetic diurnal variations. A number of reports were submitted in this section, the most important of which was that on the present state of spectrum analysis. It gave an account of recent progress both in the methods and results, together with an extended list of everything that had been published on the subject in the past few years. Papers were contributed by Mr. Preece, on the proper form of lightning-conductors, and by Mr. Richard Anderson, on the necessity of inspection of them. Dr. Tempest Anderson described an improved heliograph and an apparatus for estimating astigmatism. A powerful magnet for magneto-machines was described by Mr. Ladd, and a new form of electro-motor by Mr. Weisendanger. In the Chemical Section Dr. J. H. Gilbert gave an able summary of the state of agricultural chemistry, with an account of his own researches during a number of years, and criticism of various methods of applying chemistry to agriculture that have found advocates. The report upon the best means of obtaining light from coal-gas was the one in this section of the greatest interest to the public. It concludes that improved light must be sought in the use of more perfect burners, and that the best, fitted with governers, now made by Sugg, Peebles, and others, answer all practical purposes. In the Biological section, the principal feature was the address of the Vice-President, F. W. Balfour, before the Department of Anatomy and Physiology. He sketched briefly the progress recently made in embryology by applying the laws of variation and heredity. He contends that the evidence now in favor of the development theory is overwhelming, and there are very few naturalists who do not accept it in its main features. Dr. Sorby's address before the Geological Section was an important discussion of the structure of volcanic rocks and artificial slags, showing that a study of the process of formation of the latter throws much light upon that of the former. Professor Prestwich here took exception to the conclusions of Professor Ramsay's address regarding unvarying uniformity, contending that the superficial deposit termed "trail," "warp," and "head," in the southwest of Europe showed that this part had been submerged in recent geological times. Other papers of interest and value were those by G. M. Dawson on the "Geology of British Columbia," by Dr. Phené; on the geology of the Balearic Islands; and by Mr. W. T. Blanford on the age and relations of the Pikermi and Sewalik faunas in India. Sir J. H. Lefroy, in the Geographical Section, devoted his address to the advances made in geographical research in North America, showing that the great increase of our knowledge of this region is due to railways and the various State surveys. Among the interesting facts mentioned are the rise in the level of some American lakes, and the depths to which the ground is permanently frozen in the northern part of British North America. Though, before 1866, the surface of Salt Lake had been falling, since that time it has risen eleven feet, Pyramid Lake has risen nine feet, and Lake Winnemucca twenty-two feet. No theory of the cause was advanced. The ground at Fort Norman, on the Mackenzie River, is frozen to a depth of forty-five feet, and at York Factory, on Hudson Bay, but twenty-three feet, while at Yakutsk, Siberia, it is frozen to a depth of three hundred and eighty feet! Quite a number of papers were read in this section, showing a large and rapid increase of geographical knowledge. The most important of the public lectures was that by Mr. Francis Galton, on "Mental Imagery," which is published in the present number of the "Monthly." Professor Boyd Dawkins delivered an address on "Primeval Man," which was mainly a summary of the matter of his recent work. An account of "Professor Nordensjöld's Expedition" was given by Mr. F. Seebohm to an audience of workingmen.

The Westinghouse Automatic Brake.—The well-known Westinghouse air-brake, invented and so largely used in this country, seems to be rapidly gaining in favor abroad. The English journal "Iron," in a recent issue, highly commends it as answering all the requirements of a perfect brake, as laid down by the Board of Trade, and gives some valuable statistics concerning its use. From returns received up to the 20th of last July, it appears that the number of applications of the automatic brake throughout the world is—to engines, 3,277, and to carriages, 13,502. This is an increase in less than fourteen months of 1,594 to engines, and 6,255 to carriages. Besides this, there are 2,472 engines and 8,812 carriages fitted with the non-automatic brake—that is, the one using ordinary air-pressure. This, then, makes a total of 5,749 engines and 22,314 carriages fitted with this apparatus. In the case of 678 engines and 2,720 cars a change has been made from the non-automatic to the automatic. This equipment is divided between the different countries as follows: The United States has 2,211 engines and 7,224 cars using it; England 456 engines and 2,942 carriages; in France there are but 203 engines and 1,609 carriages; and in Belgium 197 of the former and 1,241 of the latter. The number in use in Germany, Russia, and Holland is small, ranging from 55 to 28 engines and 93 to 117 carriage equipments. A few are also in use in Italy, Sweden, and the British provinces. Certain very excellent improvements and additions "Iron" points out have recently been made to this brake system, which greatly increase its usefulness. There are a method of lighting the cars and a means of communication with the engineer by the passengers. The light is produced by carburetting air in a manner somewhat similar to that in common use in the numerous portable gas-machines. The air is reduced from the high pressure necessary to operate the brakes to a moderate and steady one. It is then passed into a small iron box containing sponges saturated with gasolene, and from these passes to the burners. The light is said to be of good quality and sufficiently bright to see to read fine print in any part of the car. Its cost is much less than gas or any other material commonly used for this purpose on railroads. The communicating apparatus consists of an arrangement of air connections, such that the pulling of a handle in the car starts a whistle on the engine and on the car, and puts the brakes partially on. The attention of the engineer being attracted, he can complete the application of the brakes if he is in a favorable position for stopping, or, if not, release them. The handle once pulled, the passenger can not return it to its place. This can only be done by one of the trainmen, so that improper use of the apparatus is readily detected. This appliance is especially designed to meet the requirements of passengers in the compartment carriages, such as are used abroad. With the American system of cars, the bell-rope furnishes a ready means of communication, while the trainmen are generally within easy call. The lighting and communicating apparatus can be added to carriages after the brake is put in, and but one connection between the carriages is required.

The Circulation of Sap in Trees.—Professor Joseph Böhm has suggested, as a theory to account for the circulation of the sap in plants, that the exhaustion of the water by evaporation from the top of the plant causes a difference in pressure in the adjoining cells, which produces a sucking up of the fluid from the cells that are relatively rich to those that are relatively poor in water. He has also endeavored to make clear what is the purpose of those vessels which run the whole length of deciduous trees, and which can be easily perceived with the naked eye in sections of many species, as the oaks, maples, etc. Generally these vessels have been regarded as air-vessels, but Professor Böhm has been convinced that in many plants they not only receive sap by measured transpiration, but also in consequence of an active exhalation take up a relatively great quantity of water, so that the air fails to penetrate them at the ordinary pressure and only escapes in considerable quantities after the plant has become drier. It has also been shown that the branches of many plants, willows for instance, notwithstanding their vessels are supplied with fluid, are able to take up more water from without, and in such quantities that twigs will increase in weight twenty

per cent. in the course of a few days. Professor Böhm's theory corresponds closely with that advanced by Professor Draper in his work on the circulation in plants and animals, and substantially agrees with the views of Herbert Spencer, as expressed in his paper on "Circulation and the Formation of Wood in Plants" ("Transactions of the Linnæan Society," March 1, 1866). It supposes that the sap-bearing cells in the whole plants are subject to a moderate pressure in consequence of the resistance which the water meets on its way from the root to the assimilating leaf. If, however, the branch can take up water through a cut end with little difficulty, a partial absorption of the contents of the vessels into the sap-bearing cells will follow, new water will pass through the cut end from without into the vessels, and the limb will become heavier. In this process, the ducts of the willow do not serve as air-tubes, but as water-canals which pour their contents into the pump-system of the sap-bearing cells. These canals become obstructed, after the cuttings have stood for some time in the water, by the growth of cells across the tubes. As soon as the flow of water through the vessels to the higher part of the limb is thus interrupted, the rapid increase of weight ceases. That the cutting does not perish at this stage, but continues to live for several months without any considerable increase of weight, is due to the fact that after the ducts have been closed the circulation of water takes place only through the sap-bearing cells and is greatly retarded. In another series of plants, as the oaks, acacias, catalpas, amorphas, etc., the ducts of the new wood have been found to be penetrable to the air, but neither air nor water could pass through the old wood, because the older veins were closed by transverse cells or gummy substances. The vessels of these plants were really air-vessels, for they held only air of the tension of the atmosphere and were destitute of sap. Yet an uninterrupted stream of sap must be kept up in such plants from the root to the top. It takes place in the same manner as in willow-cuttings, the vessels of which have been closed by transverse cells—that is, the sap is filtrated from cell to cell, so that the balance in the pressure of the contents of the adjoining cells which has been disturbed by transpiration is restored. It follows from this that the tension of the air in the upper sap-bearing cells must be very slight to make a rising of the sap possible. The exhaustion of the air finally reaches its extreme degree at an appointed age of the cells, the air in the cells is cut off from the neighboring vessels, and the factor which produces the rise of sap is thereby eliminated. The wood, which was a living sap-wood, becomes a dead heart-wood. This process is accomplished with different degrees of rapidity in different kinds of plants; even in individuals of the same species, circumstances cause many differences in the formation of heart-wood. The final result is, however, always the same, the natural death of the tree by debilitation. The thin outside layer of living wood is no longer sufficient to supply the expanded top with fluid food, no formation of new wood worthy of the name takes place, the limbs die out year by year, and finally only a feeble shoot here and there, with a few leaves of a strangely light color, indicates that there is still a little life in the stem, and this is destined soon to be extinguished. Those trees whose vessels continue to be filled with water in their old age, as the willows, birches, lindens, horse-chestnuts, etc., do not die in this manner, but through a dissolution of their sap-bearing vessels and wood-cells, opening the way for the introduction of fungi, which settle within them and attack their substance. The process of decomposition spreads and the wood is gradually reduced to dirt, till the tree finally falls or is blown to the ground.

The French Association.—The French Association for the Advancement of the Sciences held its ninth annual meeting at Rheims. The opening address was delivered by the President, M. Krantz, who referred to the growth of the Association since its organization, just after the close of the Franco-German war, and to the results of the Great Exposition of 1878. The progress of the Association has been continuous and marked from year to year, and it now numbers thirty-one hundred and fifty-six adherents. It has a capital exceeding three hundred thousand francs, and

has distributed funds in aid of investigation to the amount of about seventy thousand francs. The Secretary, M. Mercadier, stated that five hundred and seventy-two members had been enrolled since the last meeting at Montpellier to the 1st of January, 1880, and that five hundred and sixty inscriptions had been received since then. The Association receives a gift of one thousand francs a year from M. Kuhlmann; the city of Paris and the city of Montpellier, following its example, have instituted funds out of the surpluses remaining from the collections for entertaining the sessions, to provide small subventions; and M. Brunet has given twenty-three thousand eight hundred francs for the foundation of an annual subvention of one thousand francs. More than three hundred papers had been sent in at the opening of the sessions.

English and American Birds.—Mr. H. D. Minot records his impressions of English birds as compared with American in the August number of the "American Naturalist," and his good opinion of American birds is not depreciated by the comparison. Birds are less abundant in England than with us, but are, on the other hand, more accessible and companionable—for the boys in England do not stone, and the men do not shoot them, at every opportunity. They seem to be heavier and slower of flight than in America. This was observed particularly of the wild pigeon, the swift, and the grouse. Furthermore, says Mr. Minot: "I believe I may justly say that as the birds of England are inferior to those of New England in variety, so are they, on the whole, in coloring and in song. Her kingfisher may be as tropical in brilliancy as our humming-bird; her thrushes, swallows, and finches as pretty as any other of their tribe; but with the exquisite and delicate beauty of our wood-warblers, and with the splendor of our tanagers, orioles, and starlings, she has almost nothing among her familiar friends to compare. Then, among her song-birds, of whom I heard nearly all, she has none corresponding as musicians to our hermit-thrush, house-wren, water-warbler, solitary vireo, song-sparrow, or rose-crested grosbeak; yet all these, and many kindred that I might associate with them here, are good singers. To all her song-birds (that I have heard), on the contrary, except two or three, we have singers corresponding, and to all absolutely, I may say without prejudice, equals or superiors, as well as I can judge." The nightingale did not quite meet his anticipations, but he recognized that "it had a most wonderful compass, and was the greatest of all bird *vocalists*, but with a less individual and exquisite genius than our wood-thrush, yet, to hear that delicious, soft, liquid, warbled trill which she alone can give was a lasting pleasure." The flight of the skylark "is indeed astonishing, though exaggerated by report. . . . His song is an unbroken, ecstatic torrent; but it is shrill, slightly harsh, and not very musical. It is not so rich as our bobolink's roundelay, and its sweetest notes, though they suggest, do not equal, the canary's song, except for their intensity of utterance. All his poetry and the secret of his charm are in his flight." The most individual and only new type of bird-song Mr. Minot heard was that of the wood-lark, "the repetition of a delicate whistle (*ch'née*), shrill at first, intensifying as the bird rises, and, as he drops, falling in tone and pitch so as to die away upon the ear. It is exquisite." Other singers are the song-thrush, whose music is like our brown thrush's, but with less variety and occasional harsh notes; the blackbird, with a richer and more liquid and at times exceedingly delightful song; the wren, singing with characteristic sweetness and power, the black-cap linnet, and chaffinch, to whose songs Mr. Minot gives only faint and qualified praise. Robin-redbreast is charming on account of its associations. Mr. Minot earnestly commends the collections of birds in the local museums, especially those at Salisbury and Torquay.

Transformation of Sound into Light.—M. Trève, a ship captain, has described to the French Academy of Sciences an experiment with the apparatus called the singing condenser, by which he believes that he produces a transformation of sound into light. If we bring the current of a Ruhmkorff coil to bear upon one of these condensers, the latter will repeat on a larger scale the vibratory movement of the coil. The noise which it makes is due to the vibrations of the air in the condenser under the shock of

the electric current. If we put a light pressure upon the leaves of the condenser, the sound will be diminished in proportion as the pressure is increased, till it ceases. Reversing this experiment, M. Trève put a condenser into a Geissler tube, and brought the two poles of the inductive current of the Ruhmkorff coil to bear upon it through the electrodes of the tube. The tube was then connected with an air-pump. The condenser sounded as usual when the current was directed to it under the ordinary atmospheric pressure; as the air was withdrawn, the sound became more feeble, till, when a vacuum was produced, it ceased, and instead of it there shone a clear, bright light, sparkling like pearls, from the leaves of the condenser. It was not like the pale and vague light of the Geissler tubes, but something, he says, quite different, sharp and distinct—a condensed light.

Caves in Japan.—Professor Morse also described a number of artificially constructed caves which he had examined in various parts of Japan, giving sketches of them on the blackboard. These caves varied considerably in their design, but agreed in their general proportions, and were evidently intended as receptacles for the dead. They were excavated in soft rock on the sides of hills—the apertures small, and in some cases showing grooves for the adjustment of slabs of rock or other material to close them. The absence of remains in these caves could be explained by the fact that in earlier times outlaws and refugees often used them as places of shelter and residence, and laws had finally been passed by the governors of some of the districts, causing the caves to be filled up, or their entrances obstructed, to prevent their being used in this manner.

NOTES.

During an excursion to the White Mountains made in July, 1879, Mr. W. H. Pickering visited a moving mass of snow in Tuckerman ravine, which he describes as presenting many of the phenomena of an Alpine glacier, only on a greatly reduced scale. The surface of the snow was convex, being highest at the middle; where not exposed to the sun it was very hard, and differed from ice only in color. Stones previously placed upon the surface of the patch showed that the middle had a motion of about eight inches per day, the sides moving more slowly. In Mr. Pickering's opinion, it corresponds with the upper portion of a glacier, and might, perhaps, be called an incipient glacier.

An illustration of the fixedness of the characters of plants is shown from the analysis of specimens of the oleaginous Chinese pea (*Soya hispida*) from Hungary, China, and France. Only insignificant differences in composition were discovered notwithstanding the peas had grown in widely separated countries under very different conditions of climate and soil.

Professor Benjamin Peirce, F. R. S., LL. D., died in Boston October 6, 1880, aged seventy-one years. He graduated at Harvard College in 1829, was made Professor of Mathematics and Natural Philosophy in that institution in 1833, and Perkins Professor of Astronomy and Mathematics in 1842.

The minute organisms or microbes, which M. Pasteur has shown to be concerned in epidemics and contagious diseases, are so very minute that they may sometimes easily escape detection, especially in pure water. In such case they may be killed, without being deformed, by certain chemical agents, among which is osmic acid, and will sink to the bottom in such quantities as to admit of microscopic examination. The deposit may be examined after several hours (twenty-four or even forty-eight) if the water has been very pure. Coloring reagents mixed with dilute glycerine may also be used with advantage in the work.

A considerable number of the workmen engaged in the boring of the tunnel of St. Gothard were prostrated by a dangerous anemia. M. E. Perroncito, who has been investigating the causes of the disease, has found that all those who were affected by it were also troubled by certain species of parasitic worms, the mere presence of which was sufficient to account for the development of disease. This case is not an isolated one. Dr. Giaccone, a medical attendant of the St. Gothard company, states that a disease of identical character appeared during the boring of the tunnel of Fréjus.

An ostrich, long on exhibition at Rome, having been suffocated by thrusting its neck between the bars, there were found in its stomach four large stones, eleven smaller ones, seven nails, a necktie pin, an envelope, thirteen copper coins, fourteen beads, one French franc, two small keys, a piece of a handkerchief, a silver medal of the Pope, and the cross of an Italian order.

The phenomenon of the perforation of rocks by sand carried on the wind has been observed in the Valley of the Rhône in France. A very violent wind often prevails in the neighborhood of Uzès, and drives large quantities of sand against a band of quartzose pebbles contained in a tertiary soil. The pebbles contain cavities which might be believed to have been made by human hands, but which are really produced by the often renewed friction of the sandy particles against their surface.

Dr. Charles T. Jackson, distinguished as a chemist and geologist, and one of the discoverers of the anæsthetic properties and uses of ether, died at Somerville, Massachusetts, on the 29th of August, 1880, aged seventy-five years.

According to the recent census of New Zealand, the Maories or primitive inhabitants are rapidly decreasing, their numbers, which in 1861 were 55,334, having fallen in seventeen years to 43,595, or about twenty per cent. The causes given for this national decay are love of drink, bad food and clothing, neglect of cleanliness, and unwholesome dwellings. The natives of Hawaii are disappearing still more rapidly. In 1866 they numbered 57,125, and had fallen off in the next twelve years to 44,088.

The report of the experts employed to ascertain the causes of the Tay Bridge disaster is in refreshing contrast to the excusatory treatment of official recklessness and incompetency in this country. The bridge, according to this report, was badly designed, badly constructed, and badly maintained, and it tumbled down on account of defects of structure that became apparent and were patched up some time before the casualty happened. The initial blunders are laid at the door of Sir Thomas Bouch, the designer and constructor of the bridge, and General Hutchinson, the Board of Trade Inspector, has to bear the blame of allowing the bridge to be used when he knew it was in this dangerous condition.

M. Boutigny has called attention to the remarkable powers of resistance against chemical agents possessed by insects. Having put a common fly into the lye of potash, he found it in the best condition on the next day. He also found that weevils, imprisoned for a considerable time in a flask containing caustic stone and coriander-seed, prospered, multiplied, and lived as long as the seed lasted.

Samuel Sherman Haldeman, Professor of Comparative Philology in the University of Pennsylvania, died at his home in Chickies, Pennsylvania, September 10, 1880, at the age of sixty-eight.

M. Rivett Carnac, who has explored many of the barrows and burial-mounds of India, has found in them new evidences of the resemblance of the mounds and their contents to similar works in Europe. The shape of the tumuli is the same in the East and the West, and they are always placed on the slope of a hill facing the south.

Professor Forel, of Morges, Switzerland, has just published some interesting observations he has made upon the flickering of gaslights. At a distance of six miles these lights appear to the eye as star-like shining points; and from a large number of observations Professor Forel has arrived at the conclusion that their flickering is strongest when the air is still, and becomes weaker as the force of the wind increases. This appearance should not, of course, be confounded with the flickering which is produced by the wind. The study of the atmospheric conditions under which the flickering takes place might be made the starting-point for investigating the twinkling of the stars.

Fritz Müller has found a bivalve crustacean allied to Cythera, a salt-water genus, living between the leaves of the bromeliads, or plants of the pineapple tribe, which grow upon the trees in Brazil. It does not resemble any living entomostracan, but has its nearest known ally in a fossil species of the silurian strata of Bohemia. Müller has named it *Elpidium bromelliarum*. He found it in the tree-frequenting bromeliads everywhere from the seaside to nearly one hundred miles in the interior. As it can not wander from tree to tree, or even from one plant of bromelia to another, its distribution must be effected by beetles or some other bromelia-infecting forms.

By putting chloride of aluminum, the vapor of water, and metallic magnesium in a heated porcelain tube, Stanislas Meunier has produced a multitude of microscopic octahedral crystals, of extreme hardness and wholly proof against the action of fuming nitric acid, which he says have the same composition as natural spinelle. He has also produced, by the reaction of water and chloride of aluminum, hexagonal laminæ of corundum crystallized as in nature.

In a paper on Japanese *Pulmonifera*, read at the Boston meeting of the American Association, Professor Morse called attention to the occurrence of a number of species of land-snails in Yezo, identical with forms occurring in New England. He also alluded to the occurrence of two species of slugs in Japan which are common in New England. While he had met with most of fresh-water genera of *Pulmonifera* in Japan, he had never yet found a example of *Physa*.

JEAN BAPTISTE ANDRÉ DUMAS.

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THE DEVELOPMENT OF POLITICAL INSTITUTIONS.

By HERBERT SPENCER.

II.—POLITICAL ORGANIZATION IN GENERAL.

THE mere gathering of individuals into a group does not constitute them a society. A society, in the sociological sense, is formed only when, besides juxtaposition, there is coöperation. So long as members of the group do not combine their energies to achieve some common end or ends, there is little to keep them together. They are prevented from separating only when the wants of each are better satisfied by uniting his efforts with those of others than they would be if he acted alone.

Coöperation, then, is at once that which can not exist without a society, and that for which a society exists. It may be a joining of many strengths to effect something which the strength of no single man can effect; or it may be an apportioning of different activities to different persons, who severally participate in the benefits of one another's activities. The motive for acting together, originally the dominant one, may be defense against enemies; or it may be the easier obtainment of food, by the chase or otherwise; or it may be, and commonly is, both of these. In any case, however, the units pass from the state of perfect independence to the state of mutual dependence; and as fast as they do this they become united into a society rightly so called.

But coöperation implies organization. If acts are to be effectually combined, there must be arrangements under which they are adjusted in their times, amounts, and characters.

This social organization, necessary as a means to concerted action, is of two kinds. Though these two kinds generally coexist, and are

more or less interfused, yet they are distinct in their origins and natures. There is a spontaneous coöperation which grows up without thought during the pursuit of private ends; and there is a coöperation which, consciously devised, implies distinct recognition of public ends. The ways in which the two are respectively established and carried on present marked contrasts.

Whenever, in a primitive group, there begins that coöperation which is effected by exchange of services—whenever individuals find their wants better satisfied by giving certain products which they can make best in return for other products they are less skilled in making, or not so well circumstanced for making—there is initiated a kind of organization which then, and throughout its higher stages, results from endeavors to meet personal needs. The division of labor, to the last as at first, grows by experience of mutual facilitations in living. Each new specialization of industry arises from the effort of one who commences it to get profit, and establishes itself by conducing in some way to the profit of others. So that there is a kind of concerted action, with the elaborate social organization developed by it, which does not originate in deliberate concert. Though it is true that within the small subdivisions of this organization we find everywhere repeated the relation of employer and employed, of whom the one directs the actions of the other; yet this relation, spontaneously formed in the pursuit of private ends and continued only at will, is not made with conscious reference to achievement of public ends: ordinarily these are not thought of. And though, for the regulating of trading activities, there eventually arise agencies serving to adjust the supplies of commodities to the demands; yet such agencies do this not by direct stimulations or restraints, but simply by communicating information which serves to stimulate or restrain; and, further, these agencies themselves grow up not for the intended purpose of thus regulating, but in the pursuit of gain by individuals. So unintentionally has there arisen the elaborate division of labor by which production and distribution are now carried on, that only in modern days has there come a recognition of the fact that it has all along been arising.

On the other hand, that coöperation which unites the actions of individuals for a purpose immediately concerning the whole society, is a conscious coöperation, and is carried on by an organization of another kind, arising in a different way. When the primitive group has to defend itself against other groups, its members act together under further stimuli than those constituted by purely personal desires. Even at the outset, before any control by a chief exists, there is the control exercised by the group over its members; each of whom is obliged, by the *consensus* of opinion, to join in the general defense. Very soon the warrior of recognized superiority begins to exercise over each, during war, an influence additional to that exercised by the opinion of the group; and, when his authority becomes established, it

greatly furthers combined action. From the beginning, therefore, this kind of social coöperation is a conscious coöperation, and a coöperation which is not wholly a matter of choice—is often much at variance with private wishes. As the organization initiated by it develops, we see that, in the first place, the fighting division of the society displays in a more marked degree these same traits; the grades and divisions constituting an army coöperate more and more under a regulation, consciously established, of agencies which override individual volitions—or, to speak strictly, control individuals by motives which prevent them from acting as they would spontaneously act. In the second place, we see that, throughout the society as a whole, there spreads a kindred form of organization—kindred in so far that, for the purpose of maintaining the militant organization and the government which directs it, there are similarly established over citizens agencies which force them to labor more or less largely for public ends instead of private ends. And, simultaneously, there develops a further organization, still akin in its fundamental principle, which restrains individual activities in such wise that social safety shall not be endangered by the disorder consequent on unchecked pursuit of personal ends. So that this kind of social organization is distinguished from the other, as arising through conscious pursuit of public ends, in furtherance of which individual wills are constrained, first of all by the joint wills of the entire group, and afterward more definitely by the will of a regulative agency which the group evolves.

Most clearly shall we perceive the contrast between these two kinds of organization on observing that, while they are both instrumental to social welfare, they are instrumental in converse ways. That organization shown us by the division of labor for industrial purposes exhibits combined action; but it is a combined action which directly seeks and subserves the welfares of individuals, and indirectly subserves the welfare of society as a whole by preserving individuals. Conversely, that kind of organization evolved for governmental and defensive purposes exhibits combined action; but it is a combined action which directly seeks and subserves the welfare of the society as a whole, and indirectly subserves the welfares of individuals by preserving the society. Efforts for self-preservation by the units originate the one form of organization; while efforts for self-preservation by the aggregate originate the other form of organization. In the one case there is conscious pursuit of private ends only; and the correlative organization resulting from this pursuit of private ends, growing up unconsciously, is without coercive power. In the other case there is conscious pursuit of public ends; and the correlative organization, consciously established, exercises coercion.

Of these two kinds of coöperation and the structures effecting them, we are here concerned only with one. Political organization is to be understood as that part of social organization which consciously carries

on directive and restraining functions for public ends. It is true, as already hinted, and as we shall see presently, that the two kinds are mingled in various ways—that each ramifies through the other more or less according to their respective degrees of predominance. But the two are essentially different in origin and nature; and for the present we must, so far as may be, limit our attention to the last.

That the coöperation into which men have gradually risen secures to them benefits which could not be secured while, in their primitive state, they acted singly, and that, as an indispensable means to this coöperation, political organization has been, and is, advantageous, we shall see on contrasting the states of men who are not politically organized with the states of men who are politically organized in less or greater degrees.

There are, indeed, conditions under which as good an individual life is possible without political organization as with it. Where, as in the habitat of the Esquimaux, there are but few persons, and these very widely scattered; where there is no war, probably because the physical impediments to it are great and the motives to it feeble; and where circumstances make the occupations so uniform that there is little scope for the division of labor—mutual dependence can have no place, and the arrangements which effect it are not needed. Recognizing this exceptional case, let us consider the cases which are not exceptional.

The Digger Indians, "very few degrees removed from the orang-outang," who, scattered among the mountains of the Sierra Nevada, sheltering in holes and living on roots and vermin, "drag out a miserable existence in a state of nature, amid the most loathsome and disgusting squalor," differ from the other divisions of the Shoshones by their entire lack of social organization. The river-haunting and plain-haunting divisions of the race, under some, though but slight, governmental control, lead more satisfactory lives. In South America the Chaco Indians, low in type as are the Diggers, and like them degraded and wretched in their lives, are similarly contrasted with the superior and more comfortable savages around them in being dissociated. Among the Bedouin tribes, the Sherarat are unlike the rest in being divided and subdivided into countless bands which have no common chief; and they are described as being the most miserable of the Bedouins. More decided still is the contrast noted by Baker between certain adjacent African peoples. Passing suddenly, he says, from the unclothed, ungoverned tribes—from the "wildest savagedom to semi-civilization"—we come in Unyoro to a country governed by "an unflinching despot," inflicting "death or torture" for "the most trivial offenses"; but where they have developed administration, sub-governors, taxes, good clothing, arts, agriculture, architecture. So, too, concerning New Zealand when first discovered, Cook remarks that there seemed to

be greater prosperity and populousness in the regions subject to a king.

These last cases introduce us to a further truth. Not only does that first step in political organization which places individuals under the control of a tribal chief bring the advantages gained by better coöperation, but such advantages are increased when minor political heads become subject to a major political head. As typifying the evils which are thereby avoided, I may name the fact that among the Belooches, whose tribes, unsubordinated to a general ruler, are constantly at war with one another, it is the habit to erect a small mud-tower in each field, where the possessor and his retainers guard his produce—a state of things allied to, but worse than, that of the Highland clans, with their strongholds for sheltering women and cattle from the inroads of their neighbors, in days when they were not under the control of a central power. The benefits derived from such wider control, whether of a simple head or of a compound head, were felt by the early Greeks when the Amphictyonic Council established the laws that "no Hellenic tribe is to lay the habitations of another level with the ground; and from no Hellenic city is the water to be cut off during a siege." The good which results from that advance of political structure which unites smaller communities into larger ones was shown in our own country when, by the Roman conquest, the incessant fights between tribes were stopped; and again, in later days, when feudal nobles, becoming subject to a monarch, were debarred from private wars. Under its converse aspect, we see the same truth when, amid the anarchy which followed the collapse of the Carlovingian empire, princes and barons, resuming their independence, became active enemies to one another: their state being such that "when they were not at war they lived by open plunder." And the history of Europe has repeatedly, in many places and times, furnished kindred illustrations.

While political organization, as it extends itself throughout masses of increasing size, directly furthers welfare by removing that impediment to coöperation which the antagonism of individuals and of tribes causes, it indirectly furthers it in another way. Nothing beyond a rudimentary division of labor can arise in a small social group. Before commodities can be multiplied in their kinds, there must be multiplied kinds of producers; and, before each commodity can be produced in the most economical way, the different stages in the production of it must be apportioned out among special hands. Nor is this all. Neither the required complex combinations of individuals, nor the elaborate mechanical appliances which facilitate manufacture, can arise in the absence of a large community, generating a great demand.

But though the advantages gained by coöperation presuppose political organization, this political organization necessitates disadvantages;

and it is quite possible for these disadvantages to outweigh the advantages. The controlling structures have to be maintained, and the restraints they impose have to be borne; and the evils inflicted by taxation and by tyranny may become greater than the evils prevented.

Where, as in the East, the rapacity of monarchs has sometimes gone to the extent of taking from cultivators so much of their produce as to have afterward to return part for seed, we see exemplified the truth that the agency which maintains order may cause miseries greater than the miseries caused by disorder. The state of Egypt under the Romans, who, on the native set of officials, superposed their own set, and who made drafts on the country's resources not for local administration only but also for imperial administration, furnishes an instance. Beyond the regular taxes there were demands for feeding and clothing the military, wherever quartered; extra calls were continually made on the people for maintaining public works and subaltern agents; men in office were themselves so impoverished by exactions that they "assumed dishonorable employments or became the slaves of persons in power; gifts made to the government were soon converted into forced contributions; and those who purchased immunities from extortions found them disregarded as soon as the sums asked had been received. More marked still were the curses following excessive development of political organization in Gaul during the decline of the Roman Empire:

> So numerous were the receivers in comparison with the payers, and so enormous the weight of taxation, that the laborer broke down, the plains became deserts, and woods grew where the plow had been. . . . It were impossible to number the officials who were rained upon every province and town. . . . The crack of the lash and the cry of the tortured filled the air. The faithful slave was tortured for evidence against his master, the wife to depose against her husband, the son against his sire. . . . Not satisfied with the returns of the first enumerators, they sent a succession of others, who each swelled the valuation—as a proof of service done; and so the imposts went on increasing. Yet the number of cattle fell off, and the people died. Nevertheless, the survivors had to pay the taxes of the dead.

And how literally in this case the benefits were exceeded by the mischiefs is shown by the remark that "they fear the enemy less than the tax-gatherer: the truth is, that they fly to the first to avoid the last. Hence, the one unanimous wish of the Roman populace, that it was their lot to live with the barbarian."

In the same regions during later times the lesson was repeated. While internal peace and its blessings were achieved in mediæval France as fast as feudal nobles became subordinate to the king—while the central power, as it grew stronger, put an end to that primitive practice of a blood-revenge which wreaked itself on any relative of an offender, and made the "truce of God" a needful mitigation of the universal savagery; yet from this extension of political organization there presently grew up evils as great or greater—multiplication of

taxes, forced loans, groundless confiscations, arbitrary fines, progressive debasements of coinage, and a universal corruption of justice consequent on the sale of offices: the results being that many people died by famine, some committed suicide, while others, deserting their homes, led a wandering life. And then, afterward, when the supreme ruler, becoming absolute, controlled social life in all its details, through an administrative system vast in extent and ramifications, with the general result that in less than two centuries the indirect taxation alone "crossed the enormous interval between eleven millions and three hundred and eleven millions," there came the national impoverishment and misery which resulted in the great Revoultion.

Even the present time supplies kindred evidence, in sundry places. A voyage up the Nile shows every observer that the people are better off where they are remote from the center of government—where administrative agencies can not so easily reach them. Nor is it only under the barbaric Turk that this happens. Notwithstanding the boasted beneficence of our rule in India, the extra burdens and the complication of restraints it involves have the effect that the people find some of the adjacent countries preferable; the ryots in sundry places are leaving their homes and settling in the territory of the Nizam and in Gwalior.

Not only do those who are controlled suffer, from political organization, evils which greatly deduct from, and sometimes exceed, the benefits. Numerous and rigid governmental restraints shackle those who impose them as well as those on whom they are imposed. The successive grades of ruling agents, severally coercing grades below, are themselves coerced by grades above; and even the very highest ruling agent is enslaved by the system created for the preservation of his supremacy. In ancient Egypt the daily life of the king was minutely regulated alike as to its hours, its occupations, its ceremonies; so that, nominally all-powerful, he was really less free than a subject. It has been, and is, the same with other despotic monarchs. Till lately, in Japan, where the form of organization had become fixed, and where, from the highest to the lowest, the actions of life were prescribed in detail, the exercise of authority was so burdensome that voluntary resignation of it was frequent. Adams writes, "The custom of abdication is common among all classes, from the Emperor down to his meanest subject." European states have examplified this reacting tyranny. "In the Byzantine palace," says Gibbon, "the Emperor was the first slave of the ceremonies he imposed." Concerning the tedious court life of Louis le Grand, Madame de Maintenon remarks: "Save those only who fill the highest stations, I know of none more unfortunate than those who envy them. If you could only form an idea of what it is!"

So that, while the satisfaction of men's personal wants is furthered both by the maintenance of order and by the formation of aggregates

large enough to permit extensive division of labor, it is hindered both by deductions, often very great, from the products of their actions, and by the restraints imposed on their actions, usually in excess of the needs. And political control indirectly entails evils on those who exercise it as well as on those over whom it is exercised.

The stones composing a house can not be otherwise used until the house has been pulled down. If the stones are united by mortar, there must be extra trouble in destroying their present combination before they can be recombined. And if the mortar has had centuries in which to consolidate, the breaking up of the masses formed is a matter of such difficulty that building with new materials becomes more economical than rebuilding with the old.

I name these facts to illustrate the truth that any kind of arrangement stands in the way of rearrangement; and that this must be true of organization, which is one kind of arrangement. When, during the evolution of a living body, its component substance, at first relatively homogeneous, has been transformed into a combination of heterogeneous parts, there results an obstacle, always great and often insuperable, to any considerable change of structure; the more elaborate and definite the structure the greater is the resistance it opposes to alteration. And this, which is conspicuously true of an individual organism, is true, if less conspicuously, of a social organism. Though a society, composed of discrete units, and not having had its type fixed by inheritance from countless like societies, is much more plastic, yet the same principle holds. As fast as its parts are differentiated—as fast as there arise classes, bodies of functionaries, established institutions—these, becoming coherent within themselves and with one another, resist such forces as tend to modify them. The conservatism of every long-settled institution daily exemplifies this law. Be it in the antagonism of a Church to legislation interfering with its arrangements; be it in the opposition of an army to abolition of the purchase system; be it in the disfavor with which the legal profession at large has regarded law reform—we see that neither in their structures nor in their modes of action are parts that have once been specialized easily changed.

As it is true of a living body that its various acts have as their common end self-preservation, so is it true of its component organs that they severally tend to maintain themselves in their integrity. And, similarly, as it is true of a society that maintenance of its existence is the aim of its combined actions, so it is true of its separate classes and systems of officials, or other specialized parts, that the dominant aim of each is to preserve itself. Not the function to be performed, but the sustentation of those who perform the function, becomes the object in view: the result being that when the function is needless, or even detrimental, the structure still preserves itself as long as it can. In early days the history of the Knights Templars

furnished an illustration of this tendency. Down to the present time we have before us the familiar instance of trade guilds in London, which, having ceased to perform their original functions, nevertheless jealously maintain themselves for no purpose but the gratification of their members. And the accounts given in "The Black-book," of the sinecures which survived up to recent times, yield multitudinous illustrations.

The extent to which an organization resists reorganization we shall not fully appreciate until we observe that its resistance increases in a compound progression. For, while each new part is an additional obstacle to change, the formation of it implies a deduction from the forces causing change. If, other things remaining the same, the political structures of a society are further developed—if the existing institutions are extended or fresh ones set up—if, for directing social activities in greater detail, extra staffs of officials are appointed, the simultaneous results are an increase in the aggregate of those who form the regulating part and a corresponding decrease in the aggregate of those who form the part regulated. In various ways all who compose the controlling and administrative organization become united with one another and separated from the rest. Whatever be their particular duties, they are similarly related to the minor and major governing centers of their departments, and, through them, to the supreme governing center; and are habituated to like sentiments and ideas respecting the set of institutions in which they are incorporated. Receiving their subsistence through the national revenue, they tend toward kindred views and feelings respecting the raising of such revenue. Whatever jealousies there may be between their divisions, are overridden by sympathy when any one division has its existence or privileges endangered, since the interference with one division may spread to others. Moreover, they all stand in like relations to the rest of the community, whose actions are in one way or other superintended by them; and hence are led into kindred views respecting the need for such superintendence and the propriety of submitting to it. No matter what their previous political opinions may have been, they can not become public agents of any kind without being biased toward opinions congruous with their functions. So that, inevitably, each further growth of the instrumentalities which control, or administer, or inspect, or in any way direct social forces, increases the impediment to future modifications, both positively, by strengthening that which has to be modified, and negatively, by weakening the remainder; until at length the rigidity becomes so great that change is impossible and the type becomes fixed.

Nor does each further development of the regulative organization increase the obstacles to change only by relatively increasing the power of those who, as regulators, maintain the established order, and decreasing the power of those who, as the regulated, have not the same

direct interests in maintaining it. For the ideas and sentiments of a community as a whole progressively adapt themselves to the *régime* familiar from childhood, in such wise that it comes to be looked upon as natural, and as the only thing possible. In proportion as public agencies occupy a larger space in daily experience, leaving but a smaller space for other agencies, there comes a greater tendency to think of public control as everywhere needful, and a less ability to conceive of activities as otherwise controlled. At the same time the sentiments, adjusted by habit to the regulative machinery, become enlisted on its behalf, and adverse to the thought of a vacancy to be made by its absence. In brief, the general law, that the social organism and its units act and react in such ways as to become congruous, implies that every further extension of political organization increases the obstacle to reorganization, not only by increasing the strength of the regulative part and decreasing the strength of the part regulated, but also by producing in citizens thoughts and feelings in harmony with the resulting structure, and out of harmony with anything substantially different. Both France and Germany furnish examples of this truth. M. Comte, while looking forward to an industrial state, was so swayed by the ideas and sentiments appropriate to the French form of society, that his scheme of organization for the industrial state prescribes its arrangements with a definiteness and detail characteristic of the militant type, and utterly at variance with the industrial type. Indeed, he had a profound aversion to that individualism which is a product of industrial life and gives the character to industrial institutions. So, too, in Germany, we see that the Socialist party, who are regarded and who regard themselves as wishing to entirely reorganize society, are so incapable of really thinking away from the social type under which they have been born and nurtured, that their proposed social system is in essence nothing else than a new form of the system they would destroy. It is a system under which life and labor are to be arranged and superintended by public instrumentalities, omnipresent like those which already exist and no less coercive, the individual having his life even more regulated for him than now.

While, then, on the one hand, in the absence of settled arrangements, there can not be coöperation, yet coöperation of a higher kind is hindered by the arrangements which facilitate coöperation of a lower kind. Though, without some established relations among parts, there can be no combined actions, yet, the more extensive and elaborate such relations grow, the more difficult does it become to make an improved combination of actions. There is an increase of the forces which tend to fix, and a decrease of the forces which tend to unfix; until the fully-structured social organism, like fully-structured individual organism, becomes no longer adaptable.

In a living animal, formed as it is of aggregated units originally

like in kind, the progress of organization implies, not only that the units composing each differentiated part severally maintain their positions, but also that their progeny succeed to those positions. Bile-cells which, while performing their functions, grow and give origin to new bile-cells, are, when they decay and disappear, replaced by these: the cells descending from them do not migrate to the kidneys, or the muscles, or the nervous centers, to join in the performance of their duties. And, evidently, unless the specialized units each organ is made of gave origin to units similarly specialized, which remained in the same place, there could be none of those settled relations among parts which characterize the organism and fit it for its particular mode of life.

In a society, also, fixity of structure is favored by the transmission of positions and functions through successive generations. The maintenance of those class-divisions which arise as political organization advances implies the inheritance of a rank and a place in each class. Obviously, in proportion as the difficulty of rising from one grade into another is great, the social grades become settled in their relations. The like happens with those subdivisions of classes which, in some societies, constitute castes, and in other societies are partially exemplified by guilds. Where custom or law compels the sons of each trader to follow his father's occupation, there result, among the structures carrying on production and distribution, obstacles to change analogous to those which result in the regulative structures from impassable divisions of ranks. India shows this in an extreme degree; and in a less degree it was shown by the craft-guilds of early days in England, which facilitated adoption of a craft by the children of those engaged in it, and hindered adoption of it by others. Thus we may call inheritance of position and function the principle of fixity in social organization.

There is another way in which succession by inheritance, whether to class-position or to occupation, conduces to stability. It secures supremacy of the elder; and supremacy of the elder tends toward maintenance of the established order. A system under which a chief-ruler, sub-ruler, head of a clan or house, official, or any person having the power given by rank or property, has his place filled up at death by a descendant, in conformity with some accepted rule of succession, is a system under which, by implication, the young, and even the middle-aged, are excluded from the conduct of affairs. So, too, where an industrial system is such that the son, habitually brought up to his father's business, succeeds to his position when he dies, it follows in like manner that the regulative power of the elder over the processes of production and distribution is scarcely at all qualified by the power of the younger. Now, it is a truth daily exemplified that increasing rigidity of organization, necessitated by the process of evolution, produces in age an increasing strength of habit and aversion to change.

Hence it results that succession to place and function by inheritance, having as its necessary concomitant the monopoly of power by the eldest, involves a prevailing conservatism; and this further insures maintenance of things as they are.

Conversely, social change is facile in proportion as men's positions and functions are determinable by personal qualities. If, not being prevented by law or custom, members of one rank establish themselves in another rank, they in so far directly break the division between the ranks; and they indirectly weaken the division by preserving their family relations with the first, and forming new ones with the second; while, further, the ideas and sentiments prevailing in the two ranks, previously more or less different, are made to qualify one another and to modify the characters of their members. Similarly, if between subdivisions of the producing and distributing classes there are no barriers to migration, then, in proportion as migrations are numerous, influences physical and mental, following interfusion, tend to alter the natures of their units; at the same time that they perpetually check the establishment of differences of nature, caused by differences of function. Such transpositions of individuals between class and class, or group and group, must, on the average, however, be determined by the fitnesses of the individuals for their new places and duties. Intrusions will ordinarily succeed only where the intruding citizens have more than usual aptitudes for the businesses they undertake. Those who desert their original social positions and occupations are at a disadvantage in the competition with those whose positions and occupations they assume; and they can overcome this disadvantage only by force of some superiority in respect of the occupations in which they compete. This leaving of men to have their careers determined by their efficiencies we may therefore call the principle of change in social organization.

As we saw that succession by inheritance conduces in a secondary way to stability, by keeping the places of authority in the hands of those who by age are made most averse to new practices, so here, conversely, we may see that succession by efficiency conduces in a secondary way to change. Both positively and negatively the possession of power by the young facilitates innovation. While the energies are overflowing, little fear is felt of those obstacles to improvement and evils it may bring, which, to those of flagging energies, look formidable; and at the same time the greater imaginativeness that goes along with higher vitality, joined with a smaller strength of habit, facilitates acceptance of fresh ideas and adoption of untried methods. Since, then, where the various social positions come to be respectively filled by those who are experimentally proved to be the fittest, the relatively young are permitted to exercise authority, it results that succession by efficiency furthers change in social organization, indirectly as well as directly.

Contrasting the two, we thus see that, while the acquirement of function by inheritance conduces to rigidity of structure, the acquirement of function by efficiency conduces to plasticity of structure. Succession by descent favors the maintenance of that which exists. Succession by fitness favors transformation, and makes possible something better.

As previously pointed out, "complication of structure accompanies increase of mass," in social organisms as in individual organisms. When small societies are compounded into a larger society, the controlling agencies needed in the several component societies must be subordinated to a central controlling agency: new structures are required. Recompounding necessitates a kindred further complexity in the governmental arrangements; and at each of such stages of increase all other arrangements must become more complicated. As Duruy remarks: "By becoming a world in place of a town, Rome could not conserve institutions established for a single city and a small territory. . . . How was it possible for sixty millions of provincials to enter the narrow and rigid circle of provincial institutions?" The like holds where, instead of extension of territory, there is only increase of population. The contrast between the simple administrative system which sufficed in old English times for a million people and the complex administrative system at present needed for many millions sufficiently indicates this general truth.

But now, mark a corollary. If, on the one hand, further growth implies more complex structure, on the other hand changeableness of structure is a condition to further growth; and, conversely, unchangeableness of structure is a concomitant of arrested growth. Like the correlative law just noted, this law is clearly seen in individual organisms. On the one hand, the transition from the small immature form to the large mature form, in a living creature, implies that not the whole only, but all the parts have to be changed in their sizes and connections; every detail of every organ has to be modified; and this implies the retention of plasticity. On the other hand, when, on approaching maturity, the structures are assuming their final arrangement, their increasing definiteness and firmness constitute an increasing impediment to growth: the unbuilding and rebuilding required before there can be the needful readjustment become more and more difficult. So is it with a society. Augmentation of its mass necessitates change of the preëxisting structures, either by incorporation of the increment with them, or by their extension through it. Every elaboration and further settlement of the structures presents an additional obstacle to this; and, when rigidity is reached, such modifications of them as increase of mass would involve are impossible, and increase is prevented.

Hence a significant relation between the structure of a society and

its growth. While each increment of growth is aided by an appropriate organization, yet this organization, being inappropriate to a greater mass, becomes thereafter an impediment to further growth. Whence it follows that organization in excess of need prevents the attainment of that larger size and accompanying higher organization which might else have arisen.

To aid our interpretations of the special facts presently to be dealt with, we must keep in mind the foregoing general facts. They may be summed up as follows:

Coöperation is made possible by society, and makes society possible. It presupposes associated men, and men remain associated because of the benefits association yields them.

But there can not be concerted actions without agencies by which actions are in some way adjusted in their times, amounts, and kinds; and the actions can not be of various kinds without the coöperators undertaking different duties. That is to say, the coöperators must fall into some kind of organization, either voluntarily or involuntarily.

The organization which coöperation implies is of two kinds, distinct in origin and nature. The one, arising directly from the pursuit of individual ends and indirectly conducing to social welfare, develops unconsciously and is non-coercive. The other, arising directly from the pursuit of social ends and indirectly conducing to individual welfare, develops consciously and is coercive.

While, by making coöperation possible, political organization achieves benefits, deductions from the benefits are entailed by such organization. Maintenance of it is costly; and the cost may become a greater evil than the evils escaped. It necessarily imposes restraints; and these restraints may become so extreme that anarchy, with all its miseries, is preferable.

Organization as it becomes established is an obstacle to reorganization. Both by the inertia of position, and by the cohesion gradually established among them, the units of the structures formed oppose change. Self-sustentation is the primary aim of each part as of the whole; and hence parts once formed tend to continue, whether they are or are not useful. Moreover, each addition to the regulative structures implying, other things equal, a simultaneous deduction from the remainder of the society which is regulated, it results that, while the obstacles to change are increased, the forces causing change are decreased.

Maintenance of a society's organization implies that the units forming its component structures shall severally be replaced as they die. Stability is favored if the vacancies they leave are filled without dispute by descendants; while change is favored if the vacancies are filled by those who are experimentally proved to be best fitted for them. Suc-

cession by inheritance is thus the principle of social rigidity; while succession by efficiency is the principle of social plasticity.

Though to make coöperation possible, and therefore to facilitate social growth, there must be organization, yet the organization formed impedes further growth; since further growth implies reorganization, which the existing organization resists.

So that while, at each stage, better immediate results may be achieved by completing organization, they must be at the expense of better ultimate results. These are to be achieved by carrying organization at each stage no further than is needful for the orderly carrying on of social actions.

SCIENCE AND CULTURE.*

By Professor T. H. HUXLEY, F. R. S.

SIX years ago, as some of my present hearers may remember, I had the privilege of addressing a large assemblage of the inhabitants of this city, who had gathered together to do honor to the memory of their famous townsman, Joseph Priestley; and, if any satisfaction attaches to posthumous glory, we may hope that the manes of the burned-out philosopher were then finally appeased. No man, however, who is endowed with a fair share of common sense and not more than a fair share of vanity, will identify either contemporary or posthumous fame with the highest good; and Priestley's life leaves no doubt that he, at any rate, set a much higher value upon the advancement of knowledge and the promotion of that freedom of thought which is at once the cause and the consequence of intellectual progress.

Hence I am disposed to think that, if Priestley could be among us to-day, the occasion of our meeting would afford him even greater pleasure than the proceedings which celebrated the centenary of his chief discovery. The kindly heart would be moved, the high sense of social duty would be satisfied, by the spectacle of well-earned wealth, neither squandered in tawdry luxury and vainglorious show, nor scattered with the careless charity which blesses neither him that gives nor him that takes, but expended in the execution of a well-considered plan for the aid of present and future generations of those who are willing to help themselves.

We shall all be of one mind thus far. But it is needful to share Priestley's keen interest in physical science; to have learned, as he had learned, the value of scientific training in fields of inquiry apparently far remote from physical science; to appreciate, as he would

* An address delivered on the occasion of the opening of Sir Josiah Mason's Science College, at Birmingham, England, on October 1, 1880.

have appreciated, the value of the noble gift which Sir Josiah Mason has bestowed upon the inhabitants of the Midland district. For us children of the nineteenth century, however, the establishment of a college under the conditions of Sir Josiah Mason's trust has a significance apart from any which it could have possessed a hundred years ago. It appears to be an indication that we are reaching the crisis of the battle, or rather of the long series of battles, which have been fought over education in a campaign which began long before Priestley's time, and will probably not be finished just yet.

In the last century, the combatants were the champions of ancient literature on the one side, and those of modern literature on the other; but, some thirty years ago, the contest became complicated by the appearance of a third army, ranged round the banner of Physical Science. I am not aware that any one has authority to speak in the name of this new host. For it must be admitted to be somewhat of a guerrilla force, composed largely of irregulars, each of whom fights pretty much for his own hand. But the impressions of a full private, who has seen a good deal of service in the ranks, respecting the present position of affairs and the conditions of a permanent peace, may not be devoid of interest; and I do not know that I could make a better use of the present opportunity than by laying them before you.

From the time that the first suggestion to introduce physical science into ordinary education was timidly whispered, until now, the advocates of scientific education have met with opposition of two kinds. On the one hand they have been pooh-poohed by the men of business who pride themselves on being the representatives of practicality, while on the other hand they have been excommunicated by the classical scholars, in their capacity of Levites in charge of the ark of culture and monopolists of liberal education. The practical men believed that the idol whom they worship—rule of thumb—has been the source of the past prosperity, and will suffice for the future welfare of the arts and manufactures. They were of opinion that science is speculative rubbish; that theory and practice have nothing to do with one another; and that the scientific habit of mind is an impediment rather than an aid in the conduct of ordinary affairs.

I have used the past tense in speaking of the practical men—for, although they were very formidable thirty years ago, I am not sure that the pure species has not been extirpated. In fact, so far as mere argument goes, they have been subjected to such a *feu d'enfer* that it is a miracle if they have escaped. But I have remarked that your typical practical man has an unexpected resemblance to one of Milton's angels. His spiritual wounds, such as are inflicted by logical weapons, may be as deep as a well and as wide as a church-door, but, beyond shedding a few drops of ichor, celestial or otherwise, he is no whit the worse. So, if any of these opponents be left, I will not waste time in vain repetition of the demonstrative evidence of the practical value of science;

but, knowing that a parable will sometimes penetrate where syllogisms fail to effect an entrance, I will offer a story for their consideration.

Once upon a time, a boy, with nothing to depend upon but his own vigorous nature, was thrown into the thick of the struggle for existence in the midst of a great manufacturing population. He seems to have had a hard fight, inasmuch as, by the time he was thirty years of age, his total disposable funds amounted to twenty pounds. Nevertheless, middle life found him giving proof of his comprehension of the practical problems he had been roughly called upon to solve, by a career of remarkable prosperity. Finally, having reached old age with its well-earned surroundings of "honor, troops of friends," the hero of my story bethought himself of those who were making a like start in life, and how he could stretch out a helping hand to them. After long and anxious reflection this successful practical man of business could devise nothing better than to provide them with the means of obtaining "sound, extensive, and practical scientific knowledge." And he devoted a large part of his wealth, and five years of incessant work, to this end. I need not point the moral of a tale which, as the solid and spacious fabric of the Scientific College assures us, is no fable, nor can anything which I could say intensify the force of this practical answer to practical objections.

We may take it for granted then, that, in the opinion of those best qualified to judge, the diffusion of thorough scientific education is an absolutely essential condition of industrial progress, and that the college opened to-day will confer an inestimable boon upon those whose livelihood is to be gained by the practice of the arts and manufactures of the district. The only question worth discussion is, whether the conditions, under which the work of the college is to be carried out, are such as to give it the best possible chance of achieving permanent success.

Sir Josiah Mason, without doubt most wisely, has left very large freedom of action to the trustees, to whom he proposes ultimately to commit the administration of the college, so that they may be able to adjust its arrangements in accordance with the changing conditions of the future. But, with respect to three points, he has laid most explicit injunctions upon both administrators and teachers. Party politics are forbidden to enter into the minds of either, so far as the work of the college is concerned; theology is as sternly banished from its precincts; and, finally, it is especially declared that the college shall make no provision for "mere literary instruction and education."

It does not concern me at present to dwell upon the first two injunctions any longer than may be needful to express my full conviction of their wisdom. But the third prohibition brings us face to face with those other opponents of scientific education who are by no means in the moribund condition of the practical man, but alive, alert, and formidable. It is not impossible that we shall hear this express

exclusion of "literary instruction and education" from a college which, nevertheless, professes to give a high and efficient education, sharply criticised. Certainly the time was that the Levites of culture would have sounded their trumpets against its walls as against an educational Jericho. How often have we not been told that the study of physical science is incompetent to confer culture; that it touches none of the higher problems of life; and, what is worse, that the continual devotion to scientific studies tends to generate a narrow and bigoted belief in the applicability of scientific methods to the search after truth of all kinds! How frequently one has reason to observe that no reply to a troublesome argument tells so well as calling its author a "mere scientific specialist"! And, as I am afraid it is not permissible to speak of this form of opposition to scientific education in the past tense, may we not expect to be told that this, not only omission, but prohibition of "mere literary instruction and education" is a patent example of scientific narrow-mindedness?

I am not acquainted with Sir Josiah Mason's reasons for the action which he has taken; but, if, as I apprehend is the case, he refers to the ordinary classical course of our schools and universities by the name of "mere literary instruction and education," I venture to offer sundry reasons of my own in support of that action. For I hold very strongly by two convictions: The first is, that neither the discipline nor the subject-matter of classical education is of such direct value to the student of physical science as to justify the expenditure of valuable time upon either; and the second is, that, for the purpose of attaining real culture, an exclusively scientific education is at least as effectual as an exclusively literary education. I need hardly point out to you that these opinions, especially the latter, are diametrically opposed to those of the great majority of educated Englishmen, influenced as they are by school and university traditions. In their belief culture is obtainable only by a liberal education, and a liberal education is synonymous not merely with education and instruction in literature, but in one particular form of literature, namely, that of Greek and Roman antiquity. They hold that the man who has learned Latin and Greek, however little, is educated; while he who is versed in other branches of knowledge, however deeply, is a more or less respectable specialist, not admissible into the cultured caste. The stamp of the educated man, the university degree, is not for him.

I am too well acquainted with the generous catholicity of spirit, the true sympathy with scientific thought, which pervades the writings of our chief apostle of culture to identify him with these opinions; and yet one may cull from one and another of those epistles to the Philistines, which so much delight all who do not answer to that name, sentences which lend them some support. Mr. Arnold tells us that the meaning of culture is "to know the best that has been thought and said in the world." It is the criticism of life contained

in literature. That criticism regards "Europe as being for intellectual and spiritual purposes one great confederation, bound to a joint action and working to a common result; and whose members have for their common outfit a knowledge of Greek, Roman, and Eastern antiquity, and of one another. Special local and temporary advantages being put out of account, that modern nation will in the intellectual and spiritual sphere make most progress which most thoroughly carries out this programme. And what is that but saying that we, too, all of us as individuals, the more thoroughly we carry it out shall make the more progress!"

We have here to deal with two distinct propositions: The first, that a criticism of life is the essence of culture; the second, that literature contains the materials which suffice for the construction of such a criticism. I think that we must all assent to the first proposition. For culture certainly means something quite different from learning or technical skill. It implies the possession of an ideal, and the habit of critically estimating the value of things by comparison with a theoretic standard. Perfect culture should supply a complete theory of life, based upon a clear knowledge alike of its possibilities and of its limitations. But we may agree to all this, and yet strongly dissent from the assumption that literature alone is competent to supply this knowledge. After having learned all that Greek, Roman, and Eastern antiquity have thought and said, and all that modern literatures have to tell us, it is not self-evident that we have laid a sufficiently broad and deep foundation for that criticism of life which constitutes culture. Indeed, to any one acquainted with the scope of physical science, it is not at all evident. Considering progress only in the "intellectual and spiritual sphere," I find myself wholly unable to admit that either nations or individuals will really advance if their common outfit draws nothing from the stores of physical science. I should say that an army without weapons of precision, and with no particular base of operations, might more hopefully enter upon a campaign on the Rhine than a man, devoid of a knowledge of what physical science has done in the last century, upon the criticism of life.

When a biologist meets with an anomaly, he instinctively turns to the study of development to clear it up. The *rationale* of contradictory opinions may with equal confidence be sought in history.

It is, happily, no new thing that Englishmen should employ their wealth in building and endowing institutions for educational purposes. But, five or six hundred years ago, deeds of foundation expressed or implied conditions as nearly as possible contrary to those which have been thought expedient by Sir Josiah Mason. That is to say, physical science was practically ignored, while a certain literary training was enjoined as a means to the acquirement of knowledge which was essentially theological. The reason of this singular contradiction between

the actions of men alike animated by a strong and disinterested desire to promote the welfare of their fellows is easily discovered. At that time, in fact, if any one desired knowledge beyond such as could be obtained by his own observation, or by common conversation, his first necessity was to learn the Latin language, inasmuch as all the higher knowledge of the Western world was contained in works written in that language. Hence Latin grammar, with logic and rhetoric, studied through Latin, were the fundamentals of education. With respect to the substance of the knowledge imparted through this channel, the Jewish and Christian Scriptures, as interpreted and supplemented by the Romish Church, were held to contain a complete and infallibly true body of information.

Theological dicta were, to the thinkers of those days, that which the axioms and definitions of Euclid are to the geometers of these. The business of the philosophers of the middle ages was to deduce, from the data furnished by the theologians, conclusions in accordance with ecclesiastical decrees. They were allowed the high privilege of showing, by logical process, how and why that which the Church said was true must be true. And, if their demonstrations fell short of or exceeded this limit, the Church was maternally ready to check their aberrations, if need be, by the help of the secular arm.

Between the two our ancestors were furnished with a compact and complete criticism of life. They were told how the world began and how it would end; they learned that all material existence was but a base and insignificant blot upon the fair face of the spiritual world, and that nature was, to all intents and purposes, the playground of the devil; they learned that the earth is the center of the visible universe, and that man is the cynosure of things terrestrial; and more especially was it inculcated that the course of nature had no fixed order, but that it could be and constantly was altered by the agency of innumerable spiritual beings, good and bad, according as they were moved by the deeds and prayers of men. The sum and substance of the whole doctrine was, to produce the conviction that the only thing really worth knowing in this world was how to secure that place in a better which, under certain conditions, the Church promised. Our ancestors had a living belief in this theory of life, and acted upon it in their dealings with education, as in all other matters. Culture meant saintliness—after the fashion of the saints of those days; the education that led to it was, of necessity, theological; and the way to theology lay through Latin.

That the study of nature—further than was requisite for the satisfaction of every-day wants—should have any bearing on human life was far from the thoughts of men thus trained. Indeed, as nature had been cursed for man's sake, it was an obvious conclusion that those who meddled with nature were likely to come into pretty close contact with Satan. And if any born scientific investigator followed his in-

stincts he might safely reckon upon earning the reputation, and probably upon suffering the fate of a sorcerer.

Had the Western world been left to itself in Chinese isolation, there is no saying how long this state of things might have endured. But, happily, it was not left to itself. Even earlier than the thirteenth century, the development of Moorish civilization in Spain and the great movement of the Crusades had introduced the leaven which, from that day to this, has never ceased to work. At first through the intermediation of Arabic translations, afterward by the study of the originals, the western nations of Europe became acquainted with the writings of the ancient philosophers and poets, and in time with the whole of the vast literature of antiquity.

Whatever there was of high intellectual aspiration or dominant capacity in Italy, France, Germany, and England, spent itself for centuries in taking possession of the rich inheritance left by the dead civilizations of Greece and Rome. Marvelously aided by the invention of printing, classical learning spread and flourished. Those who possessed it prided themselves on having attained the highest culture then within the reach of mankind.

And justly. For, saving Dante on his solitary pinnacle, there was no figure in modern literature, at the time of the Renascence, to compare with the men of antiquity; there was no art to compete with their sculpture; there was no physical science but that which Greece had created. Above all, there was no other example of perfect intellectual freedom—of the unhesitating acceptance of reason as the sole guide to truth and arbiter of conduct.

The new learning necessarily soon exerted a profound influence upon education. The language of the monks and schoolmen seemed little better than gibberish to scholars fresh from Virgil and Cicero, and the study of Latin was placed upon a new foundation. Moreover, Latin itself ceased to afford the sole key to knowledge. The student who sought the highest thought of antiquity found only a second-hand reflection of it in Roman literature, and turned his face to the full light of the Greeks. And after a battle, not altogether dissimilar to that which is at present being fought over the teaching of physical science, the study of Greek was recognized as an essential element of all higher education.

Thus the Humanists, as they were called, won the day; and the great reform which they effected was of incalculable service to mankind. But the Nemesis of all reformers is finality; and the reformers of education, like those of religion, fell into the profound but common error of mistaking the beginning for the end of the work of reformation. The representatives of the Humanists, in the nineteenth century, take their stand upon classical education as the sole avenue to culture, as firmly as if we were still in the age of Renascence. Yet surely the present intellectual relations of the modern and the ancient

worlds are profoundly different from those which obtained three centuries ago. Leaving aside the existence of a great and characteristically modern literature, of modern painting, and, especially of modern music, there is one feature of the present state of the civilized world which separates it more widely from the Renascence than the Renascence was separated from the middle ages. This distinctive character of our own times lies in the vast and constantly increasing part which is played by Natural Knowledge. Not only is our daily life shaped by it, not only does the prosperity of millions of men depend upon it, but our whole theory of life has long been influenced, consciously or unconsciously, by the general conceptions of the universe which have been forced upon us by physical science. In fact, the most elementary acquaintance with the results of scientific investigation shows us that they offer a broad and striking contradiction to the opinions so implicitly credited and taught in the middle ages.

The notions of the beginning and the end of the world entertained by our forefathers are no longer credible. It is very certain that the earth is not the chief body in the material universe, and that the world is not subordinated to man's use. It is even more certain that nature is the expression of a definite order with which nothing interferes, and that the chief business of mankind is to learn that order and govern themselves accordingly. Moreover, this scientific "criticism of life" presents itself to us with different credentials from any other. It appeals not to authority, nor to what anybody may have thought or said, but to nature. It admits that all our interpretations of natural fact are more or less imperfect and symbolic, and bids the learner seek for truth not among words but among things. It warns us that the assertion which outstrips evidence is not only a blunder but a crime.

The purely classical education advocated by the representatives of the Humanists in our day gives no inkling of all this. A man may be a better scholar than Erasmus, and know no more of the chief causes of the present intellectual fermentation than Erasmus did. Scholarly and pious persons, worthy of all respect, favor us with allocutions upon the sadness of the antagonism of Science to their mediæval way of thinking, which betray an ignorance of the first principles of scientific investigation, an incapacity for understanding what a man of science means by veracity, and an unconsciousness of the weight of established scientific truths, which is almost comical.

There is no great force in the *tu quoque* argument, or else the advocates of scientific education might fairly enough retort upon the modern Humanists that they may be learned specialists, but that they possess no such sound foundation for a criticism of life as deserves the name of culture. And, indeed, if we were disposed to be cruel we might urge that the Humanists have brought this reproach upon themselves, not because they are too full of the spirit of the ancient Greek, but because they lack it.

The period of the Renascence is commonly called that of the "Revival of Letters," as if the influences then brought to bear upon the mind of western Europe had been wholly exhausted in the field of literature. I think it is very commonly forgotten that the revival of science, effected by the same agency, although less conspicuous, was not less momentous. In fact, the few and scattered students of Nature of that day picked up the clew to her secrets exactly as it fell from the hands of the Greeks a thousand years before. The foundations of mathematics were so well laid by them that our children learn their geometry from a book written for the schools of Alexandria two thousand years ago. Modern astronomy is the natural continuation and development of the work of Hipparchus and of Ptolemy; modern physics of that of Democritus and Archimedes; it was long before modern biological science outgrew the knowledge bequeathed to us by Aristotle, Theophrastus, and Galen.

We can not know all the best thoughts and sayings of the Greeks unless we know what they thought about natural phenomena. We can not fully apprehend their criticism of life unless we understand the extent to which that criticism was affected by scientific conceptions. We falsely pretend to be the inheritors of their culture, unless we are penetrated, as the best minds among them were, with an unhesitating faith that the free employment of reason, in accordance with scientific method, is the sole guide to truth.

Thus I venture to think that the pretensions of our modern Humanists to the possession of the monopoly of culture and to the exclusive inheritance of the spirit of antiquity must be abated, if not abandoned. But I should be very sorry that anything I have said should be taken to imply a desire on my part to depreciate the value of classical education, as it might be and as it sometimes is. The native capacities of mankind vary no less than their opportunities; and, while culture is one, the road by which one man may best reach it is widely different from that which is most advantageous to another. Again, while scientific education is yet inchoate and tentative, classical education is thoroughly well organized upon the practical experience of generations of teachers. So that, given ample time for learning and destination for ordinary life, or for a literary career, I do not think that a young Englishman in search of culture can do better than follow the course usually marked out for him, supplementing its deficiencies by his own efforts.

But for those who mean to make science their serious occupation; or who intend to follow the profession of medicine; or who have to enter early upon the business of life—for all these, in my opinion, classical education is a mistake; and it is for that reason that I am glad to see "mere literary education and instruction" shut out from the curriculum of Sir Josiah Mason's College, seeing that its inclusion would probably lead to the introduction of the ordinary smattering of

Latin and Greek. Nevertheless, I am the last person to question the importance of genuine literary education, or to suppose that intellectual culture can be complete without it. An exclusively scientific training will bring about a mental twist as surely as an exclusive literary training. The value of the cargo does not compensate for a ship's being out of trim; and I should be very sorry to think that the Scientific College would turn out none but lop-sided men. There is no need, however that such a catastrophe should happen. Instruction in English, French, and German is provided, and thus the three greatest literatures of the modern world are made accessible to the student. French and German, and especially the latter language, are absolutely indispensable to those who desire full knowledge in any department of science. But, even supposing that the knowledge of these languages acquired is not more than sufficient for purely scientific purposes, every Englishman has, in his native tongue, an almost perfect instrument of literary expression; and, in his own literature, models of every kind of literary excellence. If an Englishman can not get literary culture out of his Bible, his Shakespeare, his Milton, neither, in my belief, will the profoundest study of Homer and Sophocles, Virgil and Horace, give it to him.

Thus, since the constitution of the college makes sufficient provision for literary as well as for scientific education, and since artistic instruction is also contemplated, it seems to me that a fairly complete culture is offered to all who are willing to take advantage of it.

But I am not sure but that at this point the "practical" man, scotched but not slain, may ask what all this talk about culture has to do with an institution whose object is defined to be "to promote the prosperity of the manufactures and the industry of the country." He may suggest that what is wanted for this end is not culture, nor even a purely scientific discipline, but simply a knowledge of applied science. I often wish that this phrase, "applied science," had never been invented. For it suggests that there is a sort of scientific knowledge of direct practical use, which can be studied apart from another sort of scientific knowledge, which is of no practical utility, and which is termed "pure science." But there is no more complete fallacy than this. What people call applied science is nothing but the application of pure science to particular classes of problems. It consists of deductions from those general principles, established by reasoning and observation, which constitute pure science. No one can safely make these deductions until he has a firm grasp of the principles; and he can obtain that grasp only by personal experience of the processes of observation and of reasoning on which they are founded.

Almost all the processes employed in the arts and manufactures fall within the range either of physics or of chemistry. In order to improve them, one must thoroughly understand them; and no one has a chance of really understanding them who has not obtained that

mastery of principles and that habit of dealing with facts which is given by long-continued and well-directed purely scientific training in the physical and the chemical laboratory. So that there really is no question as to the necessity of purely scientific discipline, even if the work of the college were limited by the narrowest interpretation of its stated aims. And, as to the desirableness of a wider culture than that yielded by science alone, it is to be recollected that the improvement of manufacturing processes is only one of the conditions which contribute to the prosperity of industry. Industry is a means and not an end; and mankind work only to get something which they want. What that something is depends partly on their innate, and partly on their acquired, desires. If the wealth resulting from prosperous industry is to be spent upon the gratification of unworthy desires, if the increasing perfection of manufacturing processes is to be accompanied by an increasing debasement of those who carry them on, I do not see the good of industry and prosperity.

Now, it is perfectly true that men's views of what is desirable depend upon their characters; and that the innate proclivities to which we give that name are not touched by any amount of instruction. But it does not follow that even mere intellectual education may not, to an indefinite extent, modify the practical manifestation of the character of men in their actions, by supplying them with motives unknown to the ignorant. A pleasure-loving character will have pleasure of some sort; but, if you give him the choice, he may prefer pleasures which do not degrade him to those which do. And this choice is offered to every man, who possesses in literary or artistic culture a never-failing source of pleasures, which are neither withered by age, nor staled by custom, nor embittered in the recollection by the pangs of self-reproach.

If the institution opened to-day fulfills the intention of its founder, the picked intelligences among all classes of the population of this district will pass through it. No child born in Birmingham, henceforward, if he have the capacity to profit by the opportunities offered to him first in the primary and other schools, and afterward in the Scientific College, need fail to obtain, not merely the instruction, but the culture most appropriate to the conditions of his life.

Within these walls, the future employer and the future artisan may sojourn together for a while, and carry through all their lives the stamp of the influences then brought to bear upon them. Hence, it is not beside the mark to remind you that the prosperity of industry depends not merely upon the improvement of manufacturing processes, not merely upon the ennobling of the individual character, but upon a third condition, namely, a clear understanding of the conditions of social life on the part of both the capitalist and the operative, and their agreement upon common principles of social action. They must learn that social phenomena are as much the expression of natural laws

as any others; that no social arrangements can be permanent unless they harmonize with the requirements of social statics and dynamics; and that, in the nature of things, there is an arbiter whose decisions execute themselves.

But this knowledge is only to be obtained by the application of the methods of investigation adopted in physical researches to the investigation of the phenomena of society. Hence, I confess, I should like to see one addition made to the excellent scheme of education propounded for the college, in the shape of provision for the teaching of sociology. For, though we are all agreed that party politics are to have no place in the instruction of the college, yet in this country, practically governed as it is now by universal suffrage, every man who does his duty must exercise political functions. And, if the evils which are inseparable from the good of political liberty are to be checked, if the perpetual oscillation of nations between anarchy and despotism is to be replaced by the steady march of self-restraining freedom, it will be because men will gradually bring themselves to deal with political as they now deal with scientific questions; to be as ashamed of undue haste and partisan prejudice in the one case as in the other; and to believe that the machinery of society is at least as delicate as that of a spinning-jenny, and not more likely to be improved by the meddling of those who have not taken the trouble to master the principles of its action.

In conclusion, I am sure that I make myself the mouth-piece of all present in offering to the venerable founder of the institution, which now commences its beneficent career, our congratulations on the completion of his work; and in expressing the conviction that the remotest posterity will point to it as a crucial instance of the wisdom which natural piety leads all men to ascribe to their ancestors.—*Nature.*

EXPERIMENTS WITH THE "JUMPERS" OF MAINE.*

By GEORGE M. BEARD, M. D.

ABOUT two years ago my attention was directed by my friend Mr. W. A. Croffut to the fact that, in the northern part of Maine, especially in the region of Moosehead Lake, there were to be found a class of people who presented most incredible nervous phenomena.

These people were called in the language of that region "Jumpers" or "Jumping Frenchmen." It was claimed that all, or most of them, were of French descent and of Canadian birth, and that their occupation was mainly that of lumbering in the Maine woods. Mr.

* Read before the American Neurological Association, June, 1880.

Croffut introduced me to D. W. Craig, Esq., a gentleman who had spent much time in that portion of Maine, and who had amused himself with watching and playing with these unfortunates.

In accordance with the request of Mr. Croffut and Mr. Craig, I began at that time an investigation of the subject through all accessible sources, and this year I visited Moosehead Lake in company with my friend Dr. Edward Steese, and made the investigations herein recorded.

I found two of the Jumpers employed about the hotel. With one of them, a young man twenty-seven years of age, I made the following experiments:

1. While sitting in a chair, with a knife in his hand, with which he was about to cut his tobacco, he was struck sharply on the shoulder, and told to "throw it." Almost as quick as the explosion of a pistol, he threw the knife, and it stuck in a beam opposite; at the same time he repeated the order "throw it" with a certain cry as of terror or alarm.

2. A moment after, while filling his pipe with tobacco, he was again slapped on the shoulder and told to "throw it." He threw the tobacco and the pipe on the grass, at least a rod away, with the same cry and the same suddenness and explosiveness of movement.

3. When standing near one of the employees of the house, he was told to "strike," and he struck him violently on the cheek. I took this person into the quiet of my own room, only my friend being with me, in order that the experiments might be made without interruption or disturbance. I sat down by him, explained to him the object of my visit, conversed with him in regard to his family history and his own personal experience and observation of his peculiarity, and every now and then, during the conversation, I struck him without warning on the shoulder or on the back, or mildly kicked him; and every time he was so struck he moved his shoulders upward slightly, sometimes moving both the shoulders and the arms, with or without the peculiar cry. He knew that I was studying his case; he knew that the kicks and strokes came from me, and yet he could not avoid making a slight jump or motion, as though startled.

4. While holding a tumbler in his hand, standing near to him, I told him to "throw it." He dashed the tumbler with great violence to the floor, and then began deliberately picking up the pieces in a very quiet and patient way. Whenever I struck him quietly, easily, and in such a way that he could see I was to strike him, he made only a slight jump or movement; but when the strike or kick was unexpected, though very mild in character, he could not restrain the jumping or jerking motion; but the cry did not always appear.

5. A handkerchief was suddenly thrown before his eyes by a person walking stealthily from behind. He jumped, just as though he had been struck.

Another case in the house, a lad sixteen years of age, was not so

bad as this other, but still presented all these phenomena: he jumped when he heard any sound from behind that was sharp and unexpected, and struck and threw when ordered to do so. The crowd around the hotel, partly for my benefit, kept him constantly teased and annoyed, so that when he approached he had a stealthy, suspicious, and timid look in his eye, as though he expected each moment to be jumped.

6. This man, while playing with one of his mates, had thrown him to the ground; some one approached near and commanded "Strike him," and he struck him very hard and explosively, with both hands at a time.

7. When standing by a window, he was suddenly commanded to "jump" by a person on the other side of the window. He jumped straight up, half a foot off the floor, with a loud cry, repeating the order which had been given to him.

8. When the two Jumpers were close together, they were commanded to "strike": each struck the other simultaneously—not mild or polite, but severe and painful blows. I took one of these men to my room and quietly conversed with him, and made the same experiments with him as with the other case. I found him much less irritable than the other, and he needed usually stronger excitation to produce the phenomena.

I experimented with him in the phenomenon of repeating language that was addressed to him. When the command was uttered in a quick, loud voice, he repeated the order as he heard it, at the same time that he executed it. When told to strike, he said "Strike" at the same time that he struck; when told to throw it, he said "Throw it" at the same time that he threw whatever was in his hand. It made no difference what language was used. I tried him with the first part of the first line of Homer's "Iliad," and with the first part of Virgil's "Æneid," languages, of course, of which he knew nothing, and he repeated quickly, almost violently, the sound as it was uttered—"Menin Aida," the first part of the first line of the "Iliad," and "Arma-vi," the first part of the first line of Virgil. In order to have it repeated, it was necessary that the command should be very short, as well as quickly and strongly uttered. He would not repeat a whole line, or even half a line, but simply a word or two. In these, as in the mind-reading experiments, I was able to establish my conclusions by exclusion—that is, by proving that only the involuntary action of mind on body could produce the phenomena.

These experiments were repeated again and again, under various conditions at different times, in such a way as to satisfy myself, absolutely, that the six elements of error that apply to all experiments with living human beings were all eliminated, and that the facts obtained were the solid residuum of an exact scientific investigation.*

* The six sources of error in experimenting with living human beings are—1. Unconscious deception on the part of the subject experimented on; 2. Intentional deception on

Many strange things are done by these Jumpers. One of those with whom I experimented came very near cutting his throat the day before I reached the lake. He was shaving, and the door slammed suddenly behind him; he jumped, and, had the razor been held in a different way, he might have inflicted a severe wound. One of these Jumpers being surprised by an order to "strike," while standing before a window, struck his fist right through the glass, cutting it severely. These Jumpers have been known to strike their fists against a red-hot stove; they have been known to jump into the fire, as well as into water; indeed, no painfulness or peril of position has any effect on them; they are as powerless as apoplectics or hysterics, if not more so; the absolute victims of the orders that are given them, or of the surprises that are played upon them; they must do as they are told, though it kill them, or though it kill others. I can find no evidence that the presence of water or of fire will interfere, even in the slightest degree, with the motions which they are compelled to make. As has been made apparent by the above description, it is not necessary that the surprises should come from any human being; it is not necessary that they should be ordered to strike or to jump; any sound, from any source, that comes upon them with sufficient severity and suddenness, for which they are not forewarned and forearmed, may cause them to jump and to cry. One of those on whom I experimented told me that the falling of a tree in the woods, when unexpected, would have the same effect upon him. He said that one time he was so alarmed by the sudden crash of a tree that he not only jumped, but was perfectly entranced, so that he could not move, although the tree did not fall upon him. The explosion of a gun or pistol is almost sure to excite these Jumpers. The screech of a steam-whistle is especially obnoxious to them, few of them, so far as I have been able to learn, having been able to withstand it. On one of the lake-steamers in which I returned from the hotel, there was a Jumper who, when the screech was heard, jumped right up, so that he nearly hit his head on the upper deck. As the steamer neared the landing and came to a place where he knew the whistle would sound again, he was warned to prepare himself, and he did so with such success, that on the first screech he jumped scarcely any; on the second, however, despite his care, he raised his shoulders perceptibly, but did not jump. In many of these cases, it may be observed, a simple raising of the shoulders, a sudden impulsive movement, is all that is done, there being no cry and no movement of the hands to throw or to strike.

the part of the subject experimented on; 3. Intentional collusion of other parties; 4. Unintentional collusion of other parties; 5. Chances and coincidences; 6. Phenomena of the involuntary life. In experimenting with the Jumpers the nature of the phenomena made it easy to eliminate the main element of error, intentional deception on the part of the subject—since, unless the subject is deceived or at least surprised, the phenomena do not appear.

Although called "Jumpers," they only *jump* in a minority of the experiments, the word jumping really including all such phenomena as lifting the shoulders, raising the hands, striking, throwing, crying, and tumbling. Jumpers have been known to fall head over heels over an embankment on which they were sitting, on suddenly hearing the whistle of a locomotive; they have been known to tumble head over heels over one another, when a number of them were sitting near each other.

The order to "drop it" they are compelled to obey, as well as that to strike or to jump or to throw. On one of the steamers on the Rangeley Lakes there was a waiter who was a Jumper, and when told to "drop it" he would drop whatever he had in his hands, even if it were a plate of baked beans, on the head of one of the guests. The Jumpers with whom I experimented exhibited the same phenomena.

These phenomena suggest epilepsy, particularly in their explosive character and in the nature of the cry. The hands strike or throw with a quick, impulsive movement, which is very hard to imitate artificially. They go off like a piece of machinery; it is more like the explosion of a gun than the movement of the limbs of even an angry man; and the cry suggests that which we hear in hysteria and in epilepsy. The face does not always exhibit any change, but in some cases there is a temporary flushing, and in others a temporary pallor.

All the Jumpers agree that it tires them to be very much jumped; that they feel worse after it, more or less exhausted and nervous; they all dislike to be jumped, and avoid it when it is possible; the more they are jumped the worse they are; and that after a while in the woods, where they are constantly teased and annoyed after the day's labor is over, they are made worse; whereas, after long periods of rest they become better, are less irritable and jump less, and do not jump so easily on excitement.

Nature of this Disease.—What, now, is the pathology of this jumping? How are we to rank these phenomena among the neuroses? What relation do they bear to the great family of diseases? Are they functional or structural? Are they physical or psychical? The answer is clear: jumping is a psychical or mental form of nervous disease, and is of a functional character. Its best analogue is psychical or mental hysteria, the so-called "servant-girl hysteria," as known to us in modern days, and as very widely known during the epidemics of the middle ages. Like mental or psychical hysteria, this jumping occurs not in the weak, or the nervous, or the anæmic, but in those, as a rule, in at least good if not firm and unusual health; there are no stronger men in the woods, or anywhere, than some of these Jumpers. Although some of them are injured by being excessively jumped for the time at least, yet to the majority, if not nearly all, this injury can not be said to be of a serious character. It does not apparently shorten life, and does not bring on, so far as I can learn, any other form of

nervous disease. It can not, therefore, be said to be in any sense a disease of nervous debility. Those who suffer most from it are the very opposite of neurasthenics or anæmics ; they have none of the symptoms detailed in my work on nervous exhaustion ; they are full-blooded and strong-nerved, capable of working hard and long at the most toilsome service, and will hold themselves up full and sturdy and enduring, side by side with the hardiest men in the nation. Like "servant-girl hysteria," and like certain forms of chorea or "jerks," as they are called, which appear or have appeared in certain religious revivals, like the "Holy Rollers" * as they were called in the religious revivals of northern New Hampshire, these Jumpers are contributions to psychology more than to pathology. Far out of the range of the aided senses, far beyond the reach of the microscope, or perhaps of the spectroscope, there may be molecular changes or disturbances which manifest themselves in these jumpings and strikings and throwings as a result and correlative. But for the present, possibly for all time, we can only study this subject psychologically ; we can only approach it satisfactorily from the psychological side. Only those who clearly recognize the two distinct types of hysteria, the neurasthenic or anæmic form, which may be called *physical* hysteria, and the mental or psychical form, which may be called *psychical* hysteria, can understand the nature of this peculiar malady of the Jumpers ; but those who do comprehend and recognize these two types of hysteria will have little difficulty in comprehending the general nature of this jumping and its position among the neuroses. Some of the cases of hysteria major on which Charcot has experimented with his metals and magnets belong, as I am persuaded from personal observation, to psychical or mental rather than to physical diseases. I can find in the families of those who suffer from jumping no proof of any form of functional or organic nervous disease.

Jumping is, therefore, a *trancoidal* condition, exhibiting a part of the phenomena of trance, and bearing the same relation to trance that certain epileptoidal conditions bear to epilepsy.

Although the phenomena exhibited by the Jumpers are analogous to those of mesmeric trance, of mental hysteria of the "Jerkers" and "Holy Rollers" in revivals, they yet differ from all these and all allied forms of nervous disorder in these two respects :

1. The *momentary* character of the manifestations.

In but a second or so all the acts of the Jumper—striking, throwing, dropping, crying, jerking, or jumping—are over completely, and he is about in the same condition as before he was surprised. The explosion of the Jumper, like the explosion of a revolver, is sudden and instantaneous ; and like a revolver, also, the Jumper is at once ready for a new explosion on proper excitation. If we look at a Jumper five

* So called because they rolled over and over on the floor while under religious excitement.

seconds after he has been jumped, we see no sign or indication of what he has just done, or of what he can instantly be made to do.

On the other hand, the phenomena of trance, of mental hysteria, of the "Jerkers" or "Holy Rollers" may last in any given case from several minutes to several hours or days.*

Recent German investigations have, by an interesting coincidence, demonstrated that subjects in the mesmeric trance sometimes exhibit the phenomenon of repeating automatically what is said to them. Berger produces this effect by laying his warm hand on the neck of the mesmerized subject.

2. In the persistence and permanence of the liability to be excited.

After once the habit of jumping is formed, the subject, though varying in susceptibility at different times, is yet always capable of displaying the phenomena in a greater or less degree at any moment: once a Jumper, always a Jumper, expresses the prognosis. Epidemics of jerking and rolling are, on the contrary, limited in time and in their sphere, disappearing and dying utterly away with the excitements that give rise to them, and the habit of hysteria or of being entranced may also be outgrown.

Psychologically, these Jumpers, so far as I have been able to see or to learn, are modest, quiet, retiring, deficient in power of self-possession, conceit, and push, but no more so than many others in various races. I had been told that they were of a low order of organization—half-breeds, partly French, partly English; but in this respect I was misinformed: they are at least as intelligent and as capable of fulfilling the duties belonging to them as the average of their associates who are not Jumpers; some of them can read and write, and all whom I saw could converse in English with a reasonable degree of intelligence; possibly as much as we could expect of persons of their age and environment. But all of them, without exception, were of shrinking temperaments. In the chorea epidemics of the middle ages, or of the great religious revivals of this country, this class would be very likely to have been attacked.

Hereditary.—Before I visited Moosehead Lake, while I knew only those facts that were obtained at second or third hand, I felt quite sure that this disease would be likely to be a family inheritance. This deductive reasoning was confirmed by inductive observation. It is fully as hereditary as insanity, or epilepsy, or hay-fever, although it has no special relation to any of those forms of disease. In the family of one of those with whom I experimented there were five Jumpers, the father, two sons, and two grandchildren of the respective ages of four and seven years. In the family of another with whom I experimented there were four, all brothers. In the family of another

* In my work on "Trance" these phenomena are described in more detail than is here possible.

of whom I obtained information, but did not study, there were three cases, an uncle, a mother, and a brother. In another family there were two boys, both Jumpers. Here, then, were fourteen cases in four families. By the study of these cases, it was possible to trace the malady back at least half a century.

Endemic and contagious.—Jumping seems to be endemic, confined mainly to the north woods of Maine and to those of French descent, and is psycho-contagious—that is, can be caught by personal contact, like chorea and hysteria.

Shortly after I began these researches, I found in a copy of the London "Medical Record" brief reference to precisely similar phenomena on the other side of the globe, among the Malays. The notice was very brief, indeed, but it was sufficient to show that there was no difference in the phenomena as exhibited in these different races. I have been told that in northern Michigan these Jumpers are to be found, but have obtained no evidence on that point that is entirely satisfactory. It would not be improbable that this assertion should be proved to be true, since the class among whom Jumpers are found is somewhat migratory, although not so much so as the English and Americans.

Origin and Philosophy of the Disease.—Jumping is probably an evolution of *tickling*. Some, if not all, of the Jumpers, are ticklish —exceedingly so—and are easily irritated by touching them in sensitive parts of the body. It would appear that in the evenings, in the woods, after the day's toil, in lieu of most other sources of amusement, the lumbermen have teased each other, by tickling, and playing, and startling timid ones, until there has developed this jumping, which, by mental contagion, and by practice, and by inheritance, has ripened into the full stage of the malady as it appears at the present hour. This theory is in harmony with the general facts of physiology, and explains, better than any suggestion that has occurred to me, the history of what would otherwise appear to be without explanation, and almost outside of science. In a certain sense, we are all Jumpers; under sudden excitement, as of a blow, or a violent, unexpected sound, any person, even not very nervous, may jump and cry, somewhat as these Jumpers do, though not with all the manifestations of the Jumpers. Hysterical women, jumping and shrieking on slight excitement, we have all seen.

Everything about this subject is incredible. I do not expect that my readers will believe all, if they believe any, of what is here reported; rather they will find it easier to believe that I have been deceived; that the six sources of error that are involved in all experiments with human beings were not fully eliminated; that the Jumpers, in short, experimented with me, and not I with the Jumpers; and that, through all of this half century, the guides and physicians, the proprietors of hotels, and their neighbors, and relatives, and friends, have been the victims of intentional or unintentional fraud. But to

my own mind the most incredible fact of all is, not the existence of the phenomena, but that the phenomena have not been sooner observed by science, and that they have so long escaped the notice even of scientific men who live near or in those regions, and who frequently visit them.

Two of the best known citizens of Greenville—a town at the foot of Moosehead Lake—who have lived there very many years, if not all their lives, who have had these Jumpers in their employ, denied or doubted the existence of any of these phenomena, declaring that these so-called Jumpers were merely drunk or playing. My guide in the woods of northern New Hampshire, who had spent his whole life in those wilds, who was old enough to be a great-grandfather, denied, without reservation, the whole claim; but, after investigating the subject with me, was compelled to admit its genuineness. One of my fishing companions in the woods, a clear-brained and vigorous man of business, and a man of the world, who for seventeen years had passed his summers in these regions, knew nothing of the subject until this season when I called his attention to it. All around these districts there are physicians, not in them but near them—for in the summer season the Jumpers scatter, to a certain degree, over the farms in the vicinity—and every year physicians and men of science, experts in various realms, visit for recreation the districts where these Jumpers most abound; but if they see them they do not notice them, or if they notice them they do not understand them, or if they understand them they say nothing about them, and do not attempt to bring, or at least do not succeed in bringing, the phenomena into science.

THE AUGUST METEORS.*

By W. F. DENNING, F.R.A.S.

THE August shower of meteors forms one of the most attractive and important of the annual phenomena witnessed by astronomers, and the display is awaited every year with considerable interest, not only by a large section of habitual observers, but by many persons who have their attention called to it in a mere casual way by the frequency and brightness of the meteors. For, on the 10th of August, if the night is clear and the moonlight not very strong, a person can not be long in the open before his curiosity is excited by numbers of these "falling stars," which he will notice traveling swiftly athwart the sky, and leaving lines of phosphorescence along their paths. It is,

* For a description of the November meteor-showers, see "Popular Science Monthly," vol. xv, page 445.

however, not the business of the ordinary gazer to regard such occurrences with more than a passing interest, and he simply watches their progress with a feeling almost amounting to utter indifference. But it serves to while away a leisure hour and to give rise to some curious speculations as to the origin and end of the transient objects which now and again come before his view. The case is different with the scientific observer. He has a practical interest in the phenomenon, and zealously endeavors to record its more remarkable features as they become successively presented, and to watch with increasing diligence its further development in the later hours of the night, remembering that his notes must hereafter have some value in the general comparison of results.

Quetelet's catalogue of observed meteor-showers embraces a large number which obviously belong to the August period, but the majority occurred during the present century. This can not be ascribed to an increasing activity of the meteor-stream. It is at once explained by a greater assiduity of observation, and by the fact that the subject is

FIG. 1.—BROKEN STREAK OF A PERSEID IN PEGASUS, August 11th, 11h. 10m.

considered of more importance than formerly. Hence in more recent years the shower has been diligently looked for by many observers; and the result is that we find a large number of records of its displays. In former years it was comparatively neglected. The uncertainty attached to the whole subject rendered it unattractive, for there seemed little likelihood that it would ever become an important branch of astronomy, or yield any valuable results to the patient observer of its nightly displays. Thus we find, among historical records, only a few scattered references to this shower, and we are led, at first, to the inference that it was only rarely visible in consequence of the meteors being slightly dispersed over the orbit in former years. But the irregularities in the dates of its former apparitions may safely be ascribed to other causes than a physical peculiarity of the shower itself. The lack of interest in the subject would cause it frequently to be disregarded. Many of its exhibitions would pass wholly unobserved. Indeed, it would only be described when it recurred with such striking intensity as to force itself upon the attention as a celestial event of considerable interest. Between 811 and 841 it furnished a succession

of brilliant displays at the end of July. Then there occurred a break until eighty-three years later, when it several times reappeared with similar splendor. A wide interval of more than three hundred years brings us to the year 1243, when it seems to have been again recognized, after which, until 1709, there is only one other observation of the shower (in 1451). During the last hundred years it has, however, been frequently observed, though many of the recent displays can not be compared with those of ancient times. The intermittent and rare character of the shower, as it existed between the tenth and eighteenth centuries, proves that few returns were of a sufficiently imposing nature to be recorded, and that possibly the conditions were opposed to its appearance. If the meteors of the orbit during that period were condensed in the region of their derivative comet, then we can understand the singular paucity of observations. The earth, as it passed the node, would year after year encounter no meteors until the perihelion approach of the cluster, when possibly the display may have occurred in the daytime, and been of such brief duration as entirely to elude detection.

The entry of this stream into the solar system probably dates back to a very remote antiquity—for there are several circumstances which conspire to prove that such must have been the case, and that it preceded, by many ages, the apparition of the Leonids, Andromedes, and some of the other periodical meteor-showers. The fact that it constitutes an unbroken ring leads to the inference that it must have existed from the earliest times in order to bring about so complete a dispersion of its particles, for on its first introduction, as a comet, to the earth, it is to be assumed that it formed a condensed mass like the Leonids, and only appeared as a meteor-shower when the comet returned to perihelion. A very slight difference in the periodic times of the individual meteors following the nucleus must have eventually distributed them (by its cumulative effects) along the entire orbit. In other words, the original group must have undergone a process of lengthening out, until, at the present day, it consists of a parabolic zone of meteoric pellets, through which the earth passes annually on August 10th. Moreover, the radiant point of the shower often fails to become sharply defined. Several concentric streams of similar meteors appear to diverge from the region about η *Persei*, and their physical identity is unquestionable. They are merely the deflections or offshoots from the original system which must be greatly disturbed and contorted as the earth annually intersects it. The full effects of these perturbations can hardly be estimated : many of the particles must be diverted into new orbits, and one of the results upon the main stream may be a constant widening out, so that the apparent duration of the shower must go on increasing. It now actively extends over at least eight nights ; hence the width must exceed 10,000,000 miles. And some diminution in its intensity must occur at each return, unless there is a

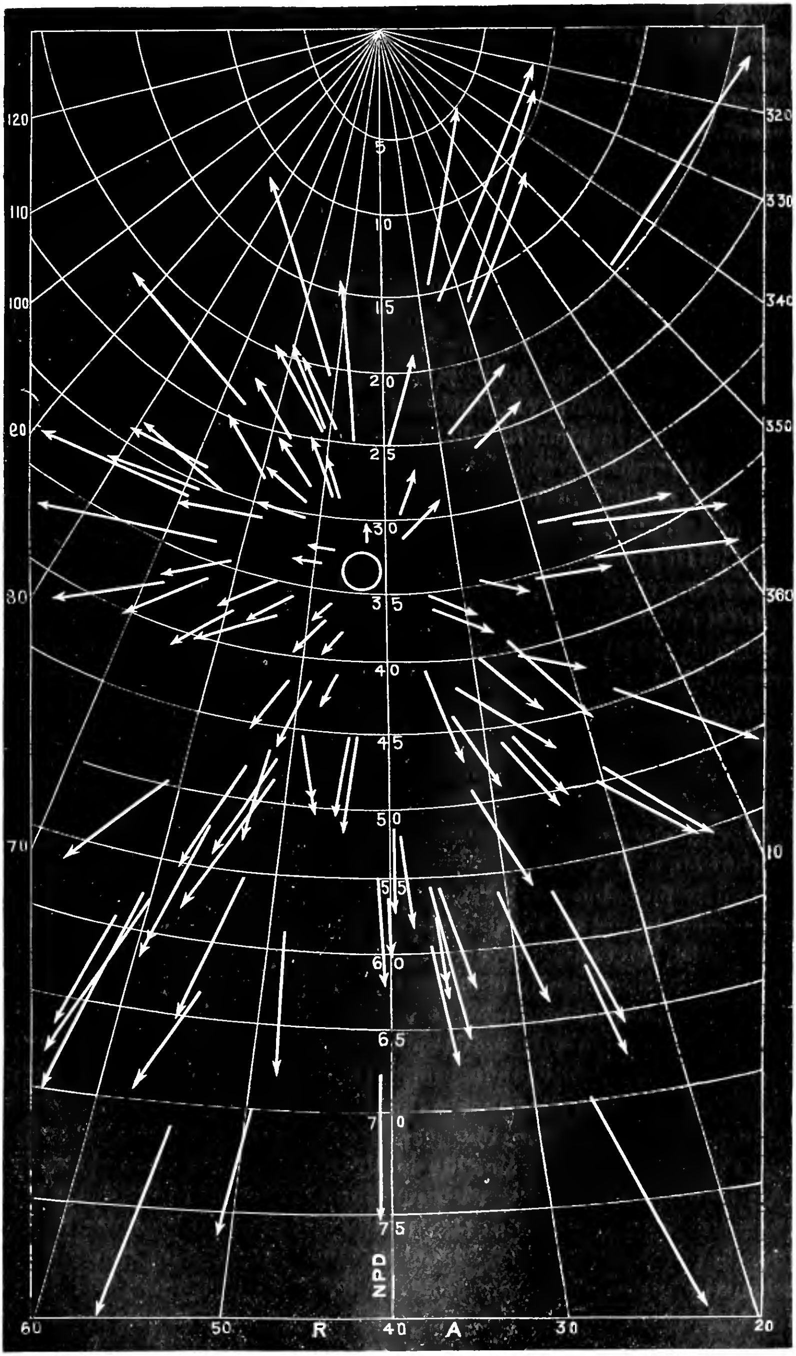


FIG. 2.—PERSEIDS NEAR THE RADIANT (44° + 57°), August 8th–12th.

source of compensation for the expenditure of its materials upon the earth. But, though many millions of the atoms are annually consumed in our atmosphere, the effect of the thinning out will be very gradual in making itself appreciable, for, as compared with the vast assemblage which constitutes the main ring, the proportion which encounters the earth is small indeed. As it is enveloped in the stream, comparatively few of the meteors are actually intercepted. By far the greater number pass by untouched. If a ball is thrown up in a thick shower of rain, it will only encounter a few drops. This may be taken as an illustration. The earth, with its diameter of 8,000 miles, can only meet with a few meteors in its rapid flight through a zone exceeding 10,000,000 miles in width.

The period of the August meteors is uncertain. Their distribution appears to have been so effectual that the element can not be determined. Some years give plentiful showers, but there have been no decided traces of regularly recurring maxima, as in the case of the Leonids. This may possibly be explained by the fact that the period is a long one, and would not become defined until after centuries of research. Comet III, 1862, which shows an exact resemblance of orbit to this system, was computed by Oppolzer to have a period of 121·5 years; and, as there occurred a fine display of the August meteors in 1863, we can not anticipate its periodical return until about 1964, if the calculations are reliable.

The August Perseids have been more frequently observed than any other system of shooting-stars, from the fact that they are visible every year with more or less distinctness, and that, as an annual shower, they can not be surpassed by any other display. The two celebrated streams of November 13th and 27th, occasionally giving rise to showers of great splendor, are periodical in character, though it is extremely probable that a few of their meteors encounter the earth at the regular return of the dates ; notwithstanding that they may elude observation in consequence either of moonlight or cloudy weather, which, indeed, generally offers some impediment to success. But the August meteors recur annually with considerable intensity, and had attracted attention at a very remote epoch, though the phenomenon was not systematically studied until later times. It was reserved for Heis at Aix-la-Chapelle to more thoroughly investigate the meteors of August, for the previous observers, though they had ascertained the fact that the month was notable in this respect, had yet neglected to obtain any important data with regard to the number or directions of the meteors seen. Schmidt also, at Bonn, began assiduously to devote himself to this special line of inquiry. The particular night in August when the meteors were most plentifully distributed was found to be the 10th, though the numbers were subject to considerable variations in different years. Schmidt, from an average of several years of observations, gave the following as the horary number of falling stars

for one observer. His results are compared with a similar average derived by Major Tupman and the writer from observations in 1869–'71 and 1877–'80 respectively:

DATE.	FALLING STARS IN ONE HOUR.		
	Schmidt.	Tupman.	Denning.
6 August.................	6	36	13
7 "	11	37	23
8 "	15	45	26
9 "	29	..	44
(max.) 10 "	31	59	71
11 "	19	53	38
12 "	7	27	24

Schmidt's figures are very small and much below the numbers found in recent years. But the averages in the table are not thoroughly reliable, inasmuch as they are based upon only a few years' observations. A longer series might give a closer comparison, but it is seldom that the results of independent observers agree within small limits. There are differences in vision, modes of observation, and in position, which must obviously affect the numbers to no small degree; and the intermittent character of the meteor-shower itself must give rise to discrepancies which can not at first sight be accounted for. The horary number of meteors on August 10th may vary, according to Heis, from 160 (in 1839) to 24 (in 1867). During the last ten years the writer has found little variation in the intensity of the annual returns when the conditions of weather and moonlight are fully taken into account; and there is no question that some of the variations ascribed to the shower have no real existence, but are to be explained by the differences referred to above.

A fair comparison can not be instituted between the horary numbers found by observers, unless the observations, from which the values are deduced, are made, in each case, at similar hours of the night; for shooting-stars, though often plentiful after midnight, are comparatively scarce in the evening hours. This is readily explained by the fact that the principal radiant points of the showers are massed together in the eastern region of the sky where the earth's orbital motion is directed, and it is obvious that in the evening hours, when the altitude of many of them is very low, and when others have scarcely appeared above the horizon, their operation is in a great measure restricted, so that only a feeble indication of their displays is perceptible at such a time. The case is entirely different at a later period of the night, when the constellations in which the several radiant points are situated have ascended high in the sky, and are in fact so placed that they may be seen to the greatest advantage. The August Perseids are always best observable in the morning hours, for the radiant point is very low on the

horizon soon after dark, and a person who persistently watches it during the night will find, with increasing elevation of the radiant, a corresponding increase in the hourly number of meteors. In 1877, at Bristol, the eastern sky was persistently watched between 9h. 30m. and 14h. 30m., when 354 meteors were seen; and, though the horary

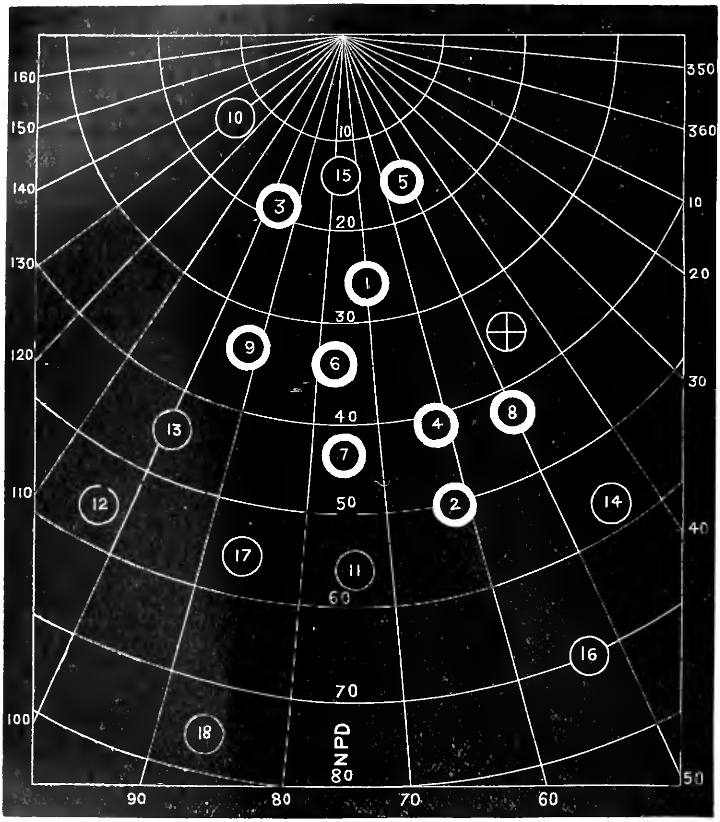
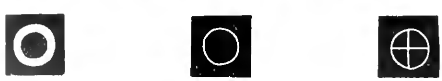


Fig. 3.—Radiant Points east of the Perseids, August 6th–12th.



Major Showers. Minor Showers. Perseids.

rate before 11h. was only 47, it rose to about 80 during the last half of the watch. Indeed, the number of meteors observed at the end of the watch was more than double the number recorded at the beginning of it. Thus it is apparent that the most favorable time for such observations is in the morning hours, and though it is generally inconvenient for amateurs to extend their vigils thus far, the importance of doing so can not be too strongly insisted on.

A typical feature of the Perseids is to be found in the streaks which frequently mark their course (Fig. 1), and serve an extremely useful purpose in enabling the directions to be registered with great accuracy. The theoretical velocity of these meteors is thirty-eight miles per second, so that they belong to the swiftest class of such bodies, and, as such, would be individually recorded with much difficulty, were it not for the special feature referred to. Their very rapid transient flights would baffle the observer as he stood endeavoring to retain the exact points of beginning and ending ; and in the majority of instances he must absolutely fail to get nearer than a mere approximation. Only in cases where the meteors sped from one star to another, or in courses parallel to closely adjoining stars, could the paths be truthfully reproduced on his map. But, fortunately for such investigations, we have no such difficulties to encounter. The phosphorescent line, almost invariably projected on the sky by the nucleus as it rushes along, remains to guide the eye in fixing its position. It is the authentic signature of the meteor gone before, and during the brief span of its endurance the observer knows how to utilize it. It is seldom these streaks last longer than three or four seconds, though in exceptional cases of Perseid fire-balls they have lingered several minutes. The writer found the average 1·8 second from many observations in August, 1880 ; and the most frequent duration is about two seconds. All the brighter meteors of the shower display them. Mr. Henry Corder, of Writtle, has observed these Perseids with great diligence in recent years, and retained many interesting notes of their peculiarities. Of 910 meteors belonging to this system, which he saw in the years 1871–'79, 526 were accompanied by streaks. These included 158 of the first magnitude, only 15 of which were devoid of streaks ; and 243 of the second magnitude, of which 72 were streakless. Among the smaller members the proportion was larger. He found the brightest meteors were generally pale-green, others orange, etc.

The luminous streaks, which are known to be the ordinary characteristic of these shooting-stars, have acquired a special significance from the fact that by their means the radiant point of the shower is capable of being ascertained with remarkable precision. This important element, to be reliably determined, must rest upon a large number of accurately recorded tracts, which intersect (on being prolonged backward) at a well-defined position. Many observers have succeeded in finding this from results of more or less value. Mr. R. P. Greg analyzed all the positions estimated prior to 1876, and gave the average at R. A. 44°, Dec. 56° north ; and Major Tupman, from a discussion of his own elaborate observations in the Mediterranean during the years 1869–'71, derived the point $45\frac{1}{2}° + 56°$, as the center of 28 sub-radiants. Evidently the two results, being founded on a large number of trustworthy records, and agreeing so closely as they did,

showed the true radiant to be situated on the northern limit of *Perseus*, close to the star *Eta* of that constellation; and more recent determinations of a similar nature have fully corroborated that as the chief diverging center of the August meteors. Many other contemporary showers have been detected in the same region of the heavens, but the shower of Perseids recurs year after year from its accustomed point.

During the last eleven years the writer at Bristol has awaited the annual returns of this shower, and the aggregate results of observations during the interval between the 6th and 12th of August show that 2,345 meteors have been recorded, of which 1,428 belonged to the

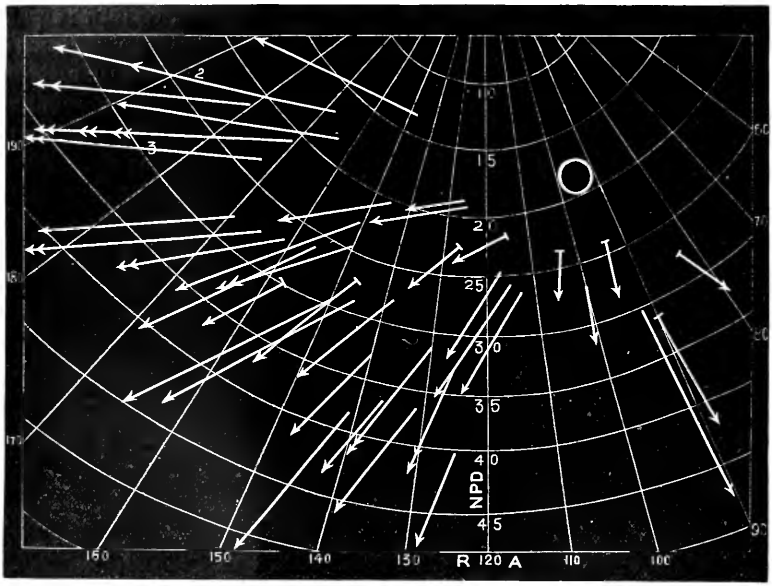


FIG. 4.—SHOWER FROM CAMELOPARDUS (96° + 71°), August 6th–12th.

display of Perseids, and 917 to other minor streams of the same epoch. In 1869 the radiant was judged to be at η *Persei*; in 1871 at *B. Camelopardi*; and in 1874 at 44° + $58\frac{1}{2}$°. The average position found during the last five years has been at 44° + 57°; and in the diagram (Fig. 2) a number of paths near this radiant are shown. Some of the meteors appear to be slightly erratic in their directions; but this may be explained either by errors of observation or by a double or diffused radiant point, which must often occasion non-conformity in the observed flights. In 1878 two points of departure were manifest from a series of precisely fixed courses at 44° + 59° and $42\frac{1}{2}$° + 54°; but in 1879 the weather interrupted observations. The present year, however, afforded an exceptionally favorable opportunity to observers, and the major radiant determined by the writer was at 44° + 56°, with the decided traces of a sub-radiant at 45° + 60°. In 1878 Major Tupman

found the shower double at 46° + 57·6° and 38° + 56° ; and in 1880 he strongly corroborated the results obtained at Bristol, though his observations were mainly confined to the night of August 9th. At the latter station the radiant apparently advanced among the stars of *Perseus*, for, while early in the month it was observed at 38° + 56°, it had shifted to 49½° + 57½° by the 13th. The same peculiarity was noted in 1877, when the following determinations were made :

	Radiant.		Radiant.
	° °		° °
August 3d–7th	40 + 56	August 12th	50 + 55
August 10th............	43 + 58	August 16th	60 + 59

There is a prominent display of meteors from the star-group χ *Persei* at the end of July and beginning of August, and it is possible that these showers may belong to the same system of concentric meteor-streams. It is certain that this fact of a progressive radiant requires fuller elucidation, and to this end observers should keep the data obtained each night separate. It may also be suggested that the radiant point should be ascertained during each hour of observation, and then, when the series are compared, any displacement must immediately become obvious, and its extent and character well defined by the observations. The meteors from *Perseus* are so numerous, and the place of divergence so readily denoted by their enduring streaks, that there will be no difficulty in an investigation of this kind. The last two years' observations have shown how exactly the radiant may be found by carefully conducted researches, and how closely the positions derived by different observers will agree on being compared together :

OBSERVER.	1879, August. Chief Radiant.	1880, August. Chief Radiant.
	° °	° °
G. L. Tupman	45 + 56	44 + 56
H. Corder..........................	45 + 57	45 + 58
E. F. Sawyer...........................	44½ + 57	44¾ + 56¼
W. F. Denning..........................	46 + 58	44 + 56

From these values a mean of 44·8° + 56·8° is derived, which is probably very near the truth. There is a secondary shower higher in declination (at about 44½° + 60°), but this is merely a branch of the same stream, for the meteors exhibit the same specialties of appearance as those common to the major shower. An apparent diffuseness of the radiant point is often brought about by imperfectly registered tracks, and by allotting the meteors of bordering showers to the radiant of the Perseids, when in fact they belong to evidently distinct families.

A few years ago the writer undertook the investigation of these co-Perseid showers from the large mass of shooting-stars which had been registered at this epoch at foreign observatories, and are contained

in the published catalogues of Heis, Schiaparelli (1872), Weiss, and Konkoly. These include many thousands of paths observed during the period from August 6th to 12th, and such of these as were obviously directed from radiant points situated eastward of *Perseus* were projected on the star-maps prepared by Professor Herschel for the purposes of the Luminous Meteor Committee of the British Association. In all 762 meteors were thus utilized, and they gave distinct evidence of the positions of a number of active streams in *Auriga* and *Camelopardus*, some of which were previously observed by Heis, and many of them have been confirmed by the writer during the last five years. The following list embraces the chief radiants thus deduced :

Meteor-Showers east of Perseus, August 6th–12th.

No.	Radiant. α δ	No. of Meteors	No	Radiant. α δ	No. of Meteors.
	° °			° °	
1	70 + 64	74	10	134 + 77	30
2	61 + 39	59	11	74 + 33	28
3	96 + 71	87	12	104 + 34	13
4	61 + 48	59	13	99 + 46	17
5	51 + 74	62	14	45 + 33	18
6	78 + 56	59	15	76 + 74	20
7	76 + 45	43	16	52 + 20	14
8	50 + 47	42	17	87 + 34	14
9	92 + 57	42	18	87 + 15	8

The relative positions of these showers are depicted in the diagram (Fig. 3), where the more prominent displays of the group are represented by deeper circles than the minor. Some of the latter can not yet be regarded as certainly established, inasmuch as they rest on slender materials.

Heis devoted much attention to the meteors of the August period during more than forty years (1833–'75), and in his extensive "results," published in 1877, gives the following as the chief radiant points for August 9th–11th :

Symbol.	Radiant. α δ	No. of Meteors.	Symbol.	Radiant. α δ	No. of Meteors.
	° °			° °	
A_{11}	45 + 52	233	Cr_{11}	273 + 56	93
B_4	330 + 55	164	St_{12}	40 + 45	118
B_5	292 + 70	135	St_{15}	56 + 70	105
Cr_5	12 + 32	93	St_{17}	27 + 21	70
Cr_6	355 + 81	103	St_{18}	25 + 58	282
Cr_8	11 + 60	192	St_{19}	295 + 44	110
Cr_9	73 + 63	125	St_{20}	51 + 75	133

But, in addition to these, there are a large number of radiants scattered over the sky, especially in the eastern quadrant. One of the most notable of these proceeds from the eastern extremity of *Aries* (44° + 25°), and supplies some bright meteors in the morning hours ; but the most conspicuous shower discovered east of *Perseus* at this epoch lies in *Camelopardus*, and in the diagram (Fig. 4) a number of its meteors, falling among the stars of *Ursa Major*, are reproduced

from the catalogues of foreign observers. This shower, however, escaped the detection of Heis and others, who had been engaged in similar investigations, though it appears to be of more importance than several radiants in its vicinity which have been independently determined by several observers. At the end of July, 1878, the writer noted a few brilliant, slow meteors, from a point at 96° + 72°, and this may have been an early evidence of the radiant which is placed in a region bare of large trees between *Telescopium* and *Polaris*. It is just north of the triangle of faint stars (*l. p. q. Camelopardi* of Bode), east of a line drawn from β *Aurigæ* to *Polaris*, and will, no doubt, be frequently reobserved in future years, though the shower of Perseids usually monopolizes attention at the epoch of its annual returns.

There is a shower near η *Persei* (No. 2), well defined, on August 6th–12th, August 21st–23d, and September 6th–15th. At the latter

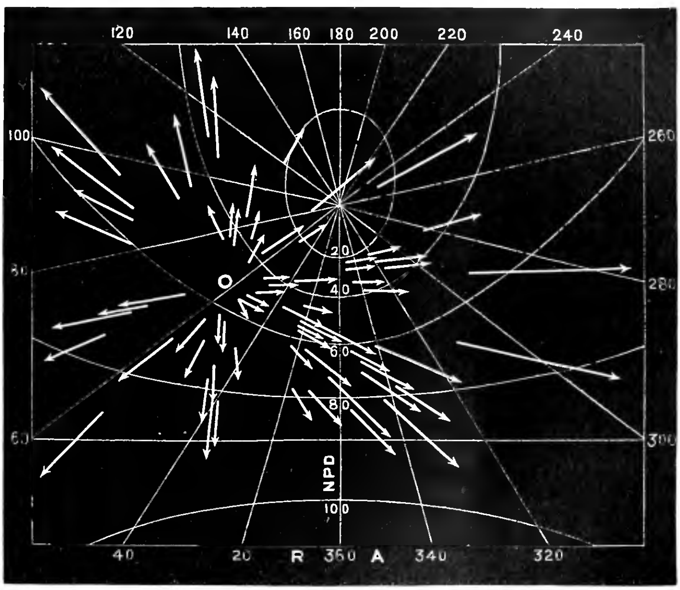


Fig. 5.—Shower of Perseids (61° + 36°), max. September 6th, 7th.

epoch it furnishes some fine meteors and constitutes a prominent display. The diagram (Fig. 5) gives the positions of eighty-six paths conforming to this radiant, observed at Bristol, and at several foreign stations in September.

The ordinary designation of Perseids for the special meteor-shower of August 10th is always understood in its individual application, though it must not be supposed that this is the only shower of Perseids visible in that month. The fact is, there are many separate showers directed from that constellation early and late in August, so that we require

some distinguishing titles or symbols to conveniently particularize either of them which it may be necessary to refer to. The method now adopted, of naming the chief periodical showers by the constellations in which their radiant points are situated, is very appropriate; and such displays as the Orionids, Leonids, and Geminids, have become so well known by their titles that it would be unwise and inconsistent to attempt reform. But with regard to the minor systems, which are becoming very numerous, and require an equally ready mode of expression, there is a great difficulty in avoiding complications.

There are certainly five nearly simultaneous showers of Perseids early in August; and in every month of the year, except May and June, meteors continue to fall from that constellation. If the present mode is adopted of styling them Perseids I, Perseids II, and so on progressively, a good deal of confusion must eventually arise as new systems are discovered; and this classification by Roman numbers, however appropriate it may be in some of its other applications, will have to give way to a more distinguishing means of reference. The name at present only gives indication of the constellation from which the meteors emanate, without regard to the date or approximate place of the radiant, and it seems to me that the difficulty may be obviated by including the nearest fixed star and the epoch with that name. To render the proposal clear, let us take the different streams proceeding from the under-mentioned points in *Perseus* in August: $44° + 56°$, $32° + 53°$, $61° + 36°$, $61° + 48°$, $46° + 47°$, which may be thus termed:

η Perseids (August 10th).
χ Perseids (August 1st–3d).
ϵ Perseids (August).
μ Perseids (August).
α Perseids (August).

This is apparently a preferable method to that of Perseids I, II, III, IV, and V, which must occasion endless trouble in references to find what special stream is meant. Moreover, the numbers seem only in fair application when affixed progressively to the successive showers of the year, for it would be hardly consistent to call a radiant visible in *Perseus* early in January by the designation of, say, "Perseids XXXVIII." Yet this is what we are drifting to, unless a fresh system is introduced to accommodate the rapidly increasing number of meteor-streams.—*Popular Science Review.*

THE EARLY PRACTICE OF MEDICINE BY WOMEN.*

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IN attempting to sketch the history of the entrance of women into the medical profession, we find the earlier periods obscured by a meagerness of material and a lack of sequence which our superficial researches have failed to supplement.

Isolated cases of gifted women attaining notable surgical skill and successfully pursuing the divine art of healing are recorded at various epochs in the history of the intellectual development of woman, but they occur at long intervals of time and in widely scattered chronicles. In the following pages we have not undertaken to present an exhaustive history or catalogue of female practitioners of medicine; we have simply collected a few scattered notices, and molded them into an outline to be hereafter filled up by a more competent hand.

These notices refer to the earlier history only, and by earlier history we mean the period prior to the establishment of medical schools for women, and to the present movement for their higher education. From the earliest times women have successfully grappled with a most difficult branch of medical science, gynecology, but long-existing and deep-seated prejudices prevented an extension of their practice, and save in exceptional cases they were forbidden both the acquirement of accurate and systematic knowledge and the exercise of their chosen vocation. So long as the practice of medicine formed a part of the priestly functions, as in ancient Egypt, the crafty guardians of superstition sedulously concealed their superior knowledge from an ignorant and credulous people, and especially from women. Yet the story of the birth of Moses shows that female gynecologists were not unknown to the Egyptians.

At a later period the Greeks thought to add dignity to the practice of medicine by forbidding it to slaves and (forsooth!) to women. During the middle ages, when every branch of science was more or less dishonored by degrading superstitions, we find women, as well as men, yielding to their influence and exercising the double calling of sorceress and healer of the sick; nor has the intelligence of the common people even in the nineteenth century reached such a height as to render the business of medical clairvoyant nugatory and profitless.

The invention of medicine was almost universally attributed by the ancients to the gods, and it is a curious fact that in both Egyptian and Grecian mythology we find female deities occupying important

* An address delivered at the commencement exercises of the Woman's Medical College of the New York Infirmary, May 27, 1880.

relations to the healing art. To the Egyptian deity Isis, the wife and sister of Osiris, peculiar medical skill was attributed, and a multitude of diseases were regarded as the effects of her anger. According to tradition she had given unequivocal proof of her power by the restoration of her son Orus to life. She was the reputed discoverer also of several remedies, and even as late as Galen the materia medica contained several compounds which bore her name: thus, in the symbolical language of the Egyptian priestly physicians, the vervain was called the "tears of Isis."

According to the annals of Grecian mythology, Hygeia, daughter of Æsculapius, the god of medicine, was worshiped in the temples of Argos as the goddess of health. In art, Hygeia is represented as a virgin wearing an expression of benevolence and kindness, and holding in one hand a serpent which is feeding from a cup in the other. She was regarded as the goddess both of physical and mental health, thereby personifying the aphorism, "Mens sana in corpore sano." The Greeks also ascribed medical power to Juno, who, under the name of Lucina, was held to preside over the birth of children, and to Ocyroé, daughter of the Centaur Cheiron, who was renowned for his skill in surgery and medicine. The sorceresses Medea and Circe were said to make use of herbs in their enchantments and for the purpose of counteracting the effects of poisons. These and similar fables probably preserve in allegoric form facts connected with the practice of medicine by women in the remotest antiquity. The writings of Homer have been examined to ascertain his testimony, but, with the exception of slight reference to woman's part in nursing wounded warriors, he contributes nothing to the subject under consideration.

The learned among the Celts, the Druids, were at the same time judges, legislators, priests, and physicians. By persuading the people that they maintained intimate relations with the gods, they succeeded in imposing their authority on the ignorant masses. "Their wives, who were called *Alraunes*, exercised the calling of sorceresses, causing considerable evil by their witchcraft, but caring for warriors wounded in battle. They gathered those plants to which they attributed magic virtues and they unraveled dreams" (Dunglison).

The first female practitioner who received a medical education appears to be Agnodice, a young Athenian woman who lived about 300 B. C. To satisfy her desire for knowledge she disguised herself in male attire, and, braving the fatal results of detection, dared to attend the schools of medicine forbidden to her sex. Among her instructors was numbered Herophilus, the greatest anatomist of antiquity and the first who dissected human subjects. After completing her studies, Agnodice preserved her disguise and practiced her chosen calling in the Grecian capital with great success, giving particular attention to the diseases of her own sex. The physicians of Athens becoming jealous of Agnodice's great reputation and lucrative practice, summoned

her before the Areopagus, and accused her of abusing her trusts in dealing with female patients. To establish her innocence, Agnodice disclosed her sex, and her persecutors then accused her of violating the law prohibiting women and slaves from studying medicine, but the wives of the most influential Athenians arose in her defense and eventually obtained a revocation of the law.

The laws and customs of the Romans, as well as of the Greeks, were antagonistic to the entrance of women into the medical profession, yet Galen, Pliny, and others have preserved the names of a few distinguished in the art of healing: Phænarete, the mother of Socrates, Olympia of Thebes, Salpe, Sotira, Elephantis, Favilla, Aspasia, and Cleopatra. Of these, details are generally wanting. Scribonius Largus writes of an "honest matron" who cured several epileptic patients by an absurd remedy, and mentions having purchased of a woman a prescription for the cure of colic, the composition of which she had learned in Africa. Why Aspasia appears in this connection is not perfectly clear; the talented wife of Pericles, renowned as "a model of female loveliness," was doubtless too involved in affairs of state to undertake the absorbing cares of the medical profession. Cleopatra, the accomplished and luxurious Queen of Egypt, of whom so many marvels are related, is named among those women possessed of medical skill; she is reported to have compounded cosmetics and to have written on the art of preserving beauty, but this statement is probably no more worthy of credence than that of the infatuated alchemists of the middle ages, who would persuade us that Cleopatra was the fortunate possessor of the philosopher's stone and of the universal solvent. In proof of the former statement, they point to her personal attractions, unchanged by increasing years, and to her immense wealth; in proof of the latter, they rely with confidence on the well-known fable of the solution of the costly pearl at the extravagant banquet to Marc Antony.

In a Roman lady named Fabiola we find an early predecessor of Florence Nightingale. She was of the illustrious house of Fabius, and was celebrated in the fourth century for piety and charity. She is to be held in grateful remembrance as the founder of hospitals in Italy, and she is said to have personally nursed the sick at Ostia. The establishment of hospitals is commonly credited to the Emperor Julian, 362 A. D., with whom Fabiola was contemporary; perhaps she took an active part in the humane movement, and held a position analogous to that of lady manager in modern times.*

Half a century later lived a woman justly distinguished for combining in one person a high degree of female loveliness, womanly virtue, and intellectual strength: though not occupied with the art of

* Celsus, who wrote in the reign of Augustus (A. D. 1), mentions large hospitals where patients were treated with specific medicines. (Milligan's Ed., p. 14.) Seneca also refers to them as "valetudinaria."

healing, we can not pass in silence the accomplished Hypatia. Born at Alexandria in the latter part of the fourth century, the daughter of Theon, an eminent mathematician and philosopher, she soon excelled her father in these branches of learning. After profiting by profound studies under celebrated masters at Athens and Alexandria, she publicly taught philosophy at both these centers of culture. Gibbon writes of her, "In the bloom of beauty and in the maturity of wisdom, the modest maid refused her lovers and instructed her disciples." On Hypatia's inhuman murder at the instigation of the jealous Cyril and his fanatical followers, it is not here necessary to dwell.

The practice of medicine by women obtained to some extent during the middle ages. Under the influence of Mohammedan rule, women were placed in excessive isolation, and it is not surprising to find under these circumstances that certain women were skilled in attending to the requirements of their own sex. Thus Albucasis, of Cordova, one of the most skillful surgeons of the twelfth century, secured the services of properly instructed women for assistance in operations on females in which considerations of delicacy intervened. Avicenna also, writing of remedies for diseases of the eyes, mentions a collyrium compounded by a woman well versed in medical science. On the whole, however, the number of women instructed in medicine among the Arabs was very small, owing possibly to the inferiority to which women were condemned by Eastern usages.

In Christian countries the nuns as well as the priests attended to the healing of the sick as an act of charity and piety. Abélard, in the twelfth century, permitted the practice of surgery to those of the convent of the Paraclete, over which Héloïse presided. The most celebrated of the learned nuns was Hildegarde (A. D. 1098–1180), abbess of the convent of Rupertsberg, near Bingen on the Rhine. She compiled a sort of materia medica, which comprises a variety of superstitious remedies. Radegonde of France, the founder of a convent at Poitiers (died 587), the pious ascetic Elizabeth of Hungary (died 1231), Hedwigia, wife of Henry the Bearded, and other women who devoted themselves to the care of the sick, may be properly regarded as praiseworthy exemplars of Christian benevolence rather than educated practitioners of medicine.

In the famous school of medicine established at Salernum by Benedictine monks in the eleventh century, we find women taking an important part. Ordericus Vitalis, in his "Ecclesiastical History" (written about 1130), relates that an abbot eminent in natural sciences, and especially distinguished in medicine, visited Salernum in the year 1059 for the purpose of discussing medical topics, and found no one erudite enough to reply to his propositions save a certain woman of great learning. This woman he does not name, but she is supposed to be the same as Trotula of Ruggiero, whose reputation at that period was world-wide. At Salernum, women were engaged in the preparation of

drugs and cosmetics, and in the practice of medicine among persons of both sexes: such were Abella, author of two medical poems; Costanza Calenda, the talented and beautiful daughter of a skillful physician, under whose instructions she attained to a doctor's degree; Mercuriade, author of several treatises; Rebecca Guarna, Adelmota Maltraversa, and Marguerite of Naples, who obtained royal authority for practicing the medical art. (Beaugrand, in "Dict. Encyc. Sci. Médicales.")

The ancient and honorable universities of Italy were, we believe, the first to recognize the capacity of women to give instruction of a high character. The University of Bologna, founded in 1116, was attended in the year 1250 by ten thousand students, engaged in the study of jurisprudence, of philosophy, and of medicine. "Here was first taught the anatomy of the human frame, the mysteries of galvanic electricity, and later the circulation of the blood." Here, too, were the earliest successful experiments in admitting women to occupy professorial chairs, for a long line of female professors taught in many departments of learning.*

As early as the thirteenth century two women were numbered among the eminent professors of the University of Bologna, Accorsa Accorso and Bettisia Gozzadini, the former held the chair of Philosophy, the latter that of Jurisprudence. In the fourteenth century the lovely and learned Novella d'Andrea, daughter of a distinguished lawyer, often took her father's place in the professorial chair, and instructed his students in law. Of Novella it is reported that she was so beautiful that she lectured behind a curtain, "lest, if her charms were seen, the students should let their young eyes wander over her exquisite features and quite forget their jurisprudence." The rival University of Padua, founded in 1228, had also its female representatives. Of these the most distinguished was Elena Lucrezia Cornaro. This interesting woman was born at Venice, June 5, 1646, and at a very early age exhibited an extraordinary capacity for acquiring languages. She was familiar with French, Spanish, Latin, Greek, and Hebrew, besides her native Italian, and had some acquaintance with Arabic. While endowed by nature with poetical and musical talents, she possessed at the same time great perseverance and capacity for serious studies, and discoursed eloquently on abstruse topics in philosophy, mathematics, astronomy, and theology. At the age of thirty-two, the University of Padua conferred upon her the degree of Doctor of Philosophy. Cornaro seems never to have held any public position, being naturally of a retiring disposition, and moreover exceedingly devoted to the order of St. Benedict. After acquiring a European reputation, she died at the comparatively early age of thirty-eight (1684).

The beginning of the following century witnessed the birth of one

* According to Madame Villari, whose papers on the "Learned Women of Bologna" furnish us with many of the succeeding data, there is to the present day no law preventing women from graduating at Italian universities or taking professorial positions.

of the most gifted women the world has ever seen. Laura Caterina Bassi was born at Bologna, October 31, 1711. She was the daughter of a distinguished lawyer and *littérateur*, and at a tender age manifested extraordinary precocity, being able while still a child to translate fluently most difficult Latin and Greek. Encouraged by her father, she pursued her studies under the guidance of eminent masters; she learned physiology and medicine with the erudite physician Gaetano Tacconi, mathematics with Manfredi, and natural philosophy with the disciples of Gassendi, and she astonished these profound philosophers by her talents. Laura Bassi studied for the pure love of knowledge, and had no ambition to seek public honors, but, to gratify the pardonable pride of a father as well as the earnest desires of her instructors, she consented to support a philosophical thesis before a learned audience of professors. This event took place on the 17th of April, 1732, before she had reached the age of twenty-one years. The occasion was made one of festivity by the whole city, who turned out to do her honor; the assemblage was presided over by two cardinals, Lambertini, afterward Pope Benedict XIV, and Grimaldi.

According to custom her thesis was opposed by seven learned men; to these she replied in elegant Latin with great success and amid the applause of the distinguished audience. A month later the degree of Doctor was conferred upon her, and she was honored by a position in the Faculty of Philosophy. The Senate subsequently bestowed upon her the chair of Physics, and commemorated the event by striking a medal which bore her own portrait. She held the professorship twenty-eight years with marked success, paying particular attention to mathematics and physics, also to *belles-lettres*. Several academies of learning elected her to membership. In 1738 she was married to J. J. Veratti, a physician, and became in the course of time the mother of twelve children. A learned French *littérateur* who visited Bologna in her day thus describes her appearance: "Laura Bassi has a countenance slightly marked with small-pox, but of a sweet and modest expression; her black eyes are sparkling, yet tranquil, and she is serious and composed in demeanor without affectation or vanity. Her memory is tenacious, her judgment sound, and her imagination active." She died in the year 1778, at the age of sixty-seven.

Laura Bassi does not seem to have pursued medical studies, and certainly never engaged in practice; but any account of the gifted women of Bologna who labored in this direction would be incomplete without a brief notice of Madame Veratti.

Contemporary with this interesting woman lived another, less gifted but scarcely less renowned. Anna Morandi was born at Bologna five years later than Laura Bassi, and died four years earlier. She became the wife of Giovanni Manzolini, a poor, hard-working maker of anatomical models. Manzolini was an expert painter and modeler in wax, and was employed by one Lelli to construct a series of anatomical

models for the use of the professors in the Institute of Bologna. Anna not only aided her husband, but soon surpassed him in skill, and particularly in that scientific knowledge upon which the success of their joint labors so largely depended. About this time Giovanni Antonio Galli, a skillful surgeon and Professor of Gynecology, opened a school of obstetrics in his house, and, encouraged by him, Anna began to lecture on anatomy to private classes. In these lectures she not only imparted with peculiar talent the knowledge derived from her husband, but she also communicated many discoveries made by herself. So great was her skill in all dissections requiring delicacy of touch and minuteness of detail, and so clearly did she demonstrate both theoretically and practically the wonderful structure of the human body, that she rapidly acquired a European reputation, and her lecture-room was frequented by students of all countries.

In 1755 Anna Manzolini became a widow, and was left with very slender means of support, but her good qualities raised up friends who secured for her a comfortable subsistence. Though she received tempting offers from other Italian universities, and even from England and Russia, she preferred to remain in her native city, Bologna. Not long after her husband's death she was appointed to the chair of Anatomy in the Bologna Institute.

Anna Morandi-Manzolini enjoys the distinction of having been the first "to reproduce in wax such minute portions of the human body as the capillary vessels and the nerves." Her collection of anatomical models, still to be seen at the Institute of Science, bears silent testimony to her remarkable skill and accurate knowledge. "Her lectures were delivered in the fragrant cedar hall which is one of the modern sights of Bologna and in which Lelli's anatomical wooden figures supporting the canopy over the professorial chair attract general admiration." In the anatomical gallery of the university is to be seen her portrait in wax, modeled by herself at the request of many admiring friends. Anna Manzolini closed a laborious and honored life in 1774, at the age of fifty-eight years.

The city of Bologna, in the middle of the eighteenth century, saw three gifted women simultaneously occupying seats in the faculty of its ancient university. Besides Laura Bassi and Anna Morandi-Manzolini, of whom we have briefly spoken, Maria Gaetano Agnesi was equally distinguished.

Maria Agnesi was born at Milan, March 16, 1718. At an early age she manifested a remarkable facility for acquiring languages, and when only twenty years old was able to discourse in French, Spanish, German, Greek, and Hebrew, besides her mother-tongue. She displayed marked ability also in philosophy and mathematics, and while still young sustained one hundred and ninety-one theses which were afterward printed under the title "Propositiones Philosophicæ." In 1748 Agnesi published a treatise on algebra, including the differential and

integral calculus, in which she displayed wonderful judgment and erudition. This work ("Instituzioni Analitichi") was afterward translated by Colson, the Lucasian Professor of Mathematics at Cambridge, and was used by the students of that university. In 1750 her father, who was Professor of Mathematics at the University of Bologna, fell sick, and she obtained permission of the good Pope Benedictus XIV to occupy her father's chair. In person Agnesi is said to have been beautiful, modest, and of pleasing manners. Her severe studies overtaxed her delicate frame, and shortly after she renounced the world and took refuge among the Blue Nuns at Bologna. In this nunnery she lived several years a devotee and an invalid; she died in 1799.

While Laura Bassi taught physics, Anna Morandi-Manzolini anatomy, and Maria Agnesi mathematics, in the Bolognese University, we might naturally expect the gentler sex to avail themselves of the opportunity of studying under their sisters' instructions. And such, in fact, was the case: the names of some of these students are recorded by the historian, many of whom received the degrees of Doctor of Philosophy and Doctor of Medicine. In 1799 Doctor Maria delle Donne appears as Professor of Medicine and Obstetrics; Clotilda Tambroni was Professor of the Greek Language and Literature, from 1793 to 1808. To these names should be added those of Novella Calderini, Maddalena Buonsignori, Dorotea Bocchi (who was both doctor and professor), Christina Roccati, Ph. D., Zaffira Ferretti, M. D., Maria Sega, M. D., and numerous graduates of Padua, Pavia, Ferrara, and other Italian universities.

Leaving the Italian Peninsula, which was so productive of remarkable personages, we will briefly examine the position of women practitioners of medicine in other parts of Europe.

Beaugrand states that the most ancient document extant relative to the organization of surgery in France forbids the practice of surgeons and of *female* surgeons who have failed to pass a satisfactory examination before the proper authorities. This paper bears the date 1311. References to female surgeons appear again in an edict of King John in 1352; from these documents it appears that women exercised the function of surgeon under legal authority. At a somewhat later period we find the calling of physician followed by women in Spain, Germany, and England.

In Spain, the Universities of Cordova, Salamanca, and Alcala honored many women with doctors' degrees. We note also the appearance at Madrid in 1587 of a learned medical work entitled "Nueva filosofia de la naturaleza del hombre," and published over the name Olivia del Sabuco. Of this person, however, nothing whatever is certainly known, and it has been conjectured that the name Olivia was a pseudonym assumed by some eminent physician.

In Germany many women cultivated medical science: Barbara Weintrauben was an author of no great merit; the Duchess Eleanor of

Troppau, Catharina Tissheim, Helena Aldegunde, and Frau Erxleben are deserving passing notice. The last mentioned was one of the most successful female practitioners of the last century. Her maiden name was Dorothea Leporin, but she is best known as Frau Erxleben. Fräulein Leporin pursued her medical studies at the University of Halle, and obtained a diploma in 1734. She settled in the little town of Quedlinburg, at the foot of the Hartz Mountains, became the wife of the rector of the Church of St. Nicholas in the same place, industriously practiced her profession, and became eminent for her skill and learning. Her son, J. C. P. Erxleben, inherited from his mother a love of scientific pursuits and became a distinguished naturalist and professor in the University of Göttingen.

In England, Anna Wolley and Elizabeth of Kent were occupied with the preparation of drugs as early as the seventeenth century, and both published works on medical subjects.

In this hasty and superficial sketch of the history of the early practice of medicine by women we would not be true to the facts if we omitted mention of certain ignorant and vulgar women who assumed medical knowledge and medical skill to impose upon a too credulous public. That avaricious women, fond of notoriety and careless of their reputation, should imitate the methods adopted in every age by unprincipled men, is not surprising, though it may be mortifying. To this class belonged Louise Bourgeois, nurse to Marie de' Medici, the Queen of Henry IV of France; though an ignorant charlatan, she acquired extraordinary influence over her royal patroness, and her career abounds in curious, eventful episodes. She was the author of several medical treatises on the diseases of women, one of which was published at Paris in 1617.

A century later another female practitioner flourished, of whom women have no reason to be proud. In the year 1738 Mrs. Joanna Stephens proclaimed in London that she had discovered a sovereign remedy for a painful disease. Notwithstanding her gross ignorance and vulgar demeanor, she secured a large circle of patients from among the upper and wealthy classes, and, after enriching herself by enormous fees drawn from their credulity, she proposed to make her medical discovery public in consideration of the modest sum of twenty-five thousand dollars. A subscription was started for this purpose and enthusiastically taken up; the clergy, lords, and ladies, with an inexplicable infatuation, hastened to add their names to the list of subscribers. Failing, however, to raise so large a sum of money, Mrs. Stephens's friends obtained a grant of the desired amount from Parliament. The certificate testifying to the "Utility, Efficacy, and Dissolving Power of the Medicines," bears the date March 5, 1739, and is signed by twenty justices. These dearly purchased remedies were three in number, "a Powder, a Decoction, and Pills." The powder consisted of calcined egg-shells and snails; the decoction was a dis-

gusting mixture of herbs, soap, and honey, boiled in water; and the pills were made of "calcined wild-carrot seeds, burdock-seeds, ashen keys, hips, and haws—all burned to a blackness—soap and honey."

Contemporary with Mrs. Stephens lived another impostor, Mrs. Mapp, sometimes known as "Crazy Sally of Epsom," and described as an "enormously fat, ugly creature, accustomed to frequent country fairs, about which she loved to reel, screaming, abusive, and in a state of beastly intoxication." This attractive lady was by profession a bone-setter, and was patronized by patients of rank and wealth, who sought her charily bestowed favors with ill-disguised contempt of her person. The town authorities of Epsom greatly esteemed Mrs. Mapp, or, perhaps we should say, highly valued the benefit the town derived from the influx of wealthy patients, and they offered her the sum of five hundred dollars per annum if she would continue to reside in the town.

The first half of this century has witnessed the career of a few women eminent in the art of healing; in France Madame La Chapelle had an extensive gynecological practice, and Madame Boivin attained to such distinction that she was honored with the degree of Doctor of Medicine by the University of Marburg. In Germany Charlotte Heidenreich and Frau Heiland, her step-mother, were similarly honored with doctors' diplomas.

It is the glory of America that she is distinguished above all countries not only as the cradle of liberty but also as the foster-mother of the intellectual advancement of women. Yet this has not always been the case; in the early chronicles of the colonists (themselves refugees from persecution) we find, strangely enough, many laws of an exacting and repressive character, some of which were aimed directly at the ambition and zeal of women. In the famous Blue Laws of Connecticut the following curious entry occurs under the date of March, 1638: "Jane Hawkins, the wife of Richard Hawkins, had liberty till the beginning of the third month called May, and the magistrates (if shee did not depart before) to dispose of her; and in the mean time shee is not to meddle in surgery or phisick, drinks, plaisters or oyles, nor to question matters of religion except with the Elders for satisfaction." ("True Blue Laws of Connecticut," by J. H. Trumbull, 1876.)

A hundred and forty years later we find marked progress in liberality in the State of Connecticut. As early as 1773, in the town of Torrington, Litchfield County, two women were greatly honored and much sought for on account of their remarkable skill as accoucheuses. The first of these, Mrs. Jacob Johnson, to quote the historian of Torrington (Rev. Samuel Orcutt), was as thoroughly known and trusted in her profession as any physician that was ever in the town. "She rode on horseback, keeping a horse for the special purpose, and traveling night and day, far and near," to meet her engagements. "She kept an account of the number of cases she had, and the success

of the patients, and the new-comers, and of these last there is at least one living in the town. In the midst of her usefulness she was removed by death, and it became a great inquiry, 'Who will take the place of Granny Johnson?'" This question was answered in the person of Mrs. Huldah Beach, daughter of Aaron Loomis, Jr., more successfully than was anticipated. Mrs. Beach became as celebrated in her calling as Granny Johnson, and continued to attend to her professional duties until an advanced age. She was a woman of remarkably fine personal appearance and decided dignity of carriage, yet marked kindliness of manner. Her intellectual strength and ability were perceptible to every one, and she in consequence commanded great respect in all classes of society, and won the confidence of the people so that but few calls were made on any other physician in her specialty, on the western side of the town. She also rode as far as Winchester, Goshen, and Litchfield.

Dr. Orcutt, whose "History of Torrington" has furnished us with these particulars, remarks in this connection, "Many have imagined that, in the practice of medicine by women, a new era has arrived, but in this there is only a 'restoration of the lost arts.'"

Our allotted task is completed, yet we can not close this address without a brief survey of the present period, in which the facilities afforded women in all branches of learning contrast strongly with the formerly wellnigh insurmountable impediments and obstacles.

Women desirous of acquiring medical knowledge are no longer obliged to disguise themselves in male attire like Agnodice the Athenian, nor are practitioners liable to suffer the penalties of the law for their works of benevolence and charity. In 1880 the young woman with aspirations for intellectual culture finds open to her such excellent training-schools as Holyoke, Wells, and Rutgers, such noble institutions as Vassar, Smith, and Wellesley. Does she not shrink from contact with her brothers, she may gain entrance into many universities, either expressly founded in a liberal spirit, as Oberlin, Cornell, and Ann Arbor, or which have yielded to the steady pressure of public opinion, and now open their doors more or less widely to the gentler sex. To enumerate the latter would be tedious and unprofitable; suffice it to say that even venerable and aristocratic Harvard has lately joined the number, and our own Columbia, should her President's views prevail, will not be slow to follow.

The young woman who seeks intellectual training of a more technical character, with a view to adopting a professional career, will find many avenues opening up with constantly increasing privileges and facilities. The student in art, thanks to the philanthropy of our venerable citizen, Peter Cooper, can, without incurring expense, acquire a knowledge of designing or of wood-engraving which will hardly fail to secure for her a competence. The student in biology will receive her share of attention at a summer school of science on our Atlantic

seaboard, or held in connection with some enterprising institution of learning. The student in pharmacy and chemistry can conduct her researches on an equality with men, or, if she prefer, in laboratories controlled and officered in large part by women themselves.

The student in medicine now gains access to medical colleges in nearly every State in the Union, and the legitimacy of her pursuit as well as her ability to grapple with it gains increasing advocates. "She is no longer regarded as too good and too stupid to study medicine." The candidate for medical honors also finds in Boston, Philadelphia, New York, and Chicago, well-appointed schools of medicine especially adapted to her needs, with corps of trained and sympathizing instructors ready to lend a helping hand.

Looking across the Atlantic, we find countries so lately intolerant of the intellectual advancement of woman at last yielding, not always gracefully, to the inevitable. The little republic of Switzerland and the mighty empire of Russia have for many years manifested practical sympathy with the cause; and now, slowly yet surely, conservative England begins to recognize the fact that the Anglo-Saxon race, with its boasted love of liberty, has been neglectful of its duty to womankind.

To trace any more fully the history of the recent period does not fall within the province of our address; we look to the pioneers of this movement who are still with us for an exhaustive and authentic record such as participators and eye-witnesses alone can supply.

METHODS IN INDUSTRIAL EDUCATION.*

By Professor SILVANUS P. THOMPSON.

SHALL we have a school in the workshop, or a workshop in the school? Or what other combination can we devise that will permit mental and scientific training to proceed after the age has been attained at which serious manual labor must begin? Hitherto we have been contented at most to organize night schools, evening classes, and so-called Mechanics' Institutes for our apprentices, leaving it to their own caprice whether they chose to employ their leisure hours in self-improvement or squander them in self-indulgence. On the Continent of Europe somewhat different ideas have prevailed. In Belgium, Switzerland, Germany, France, and even Russia, there are innumerable examples of Technical Schools and Polytechnic Schools of all descriptions, which profess to teach with greater or less completeness the

* Continuation of article from the September "Contemporary Review," entitled "The Apprenticeship of the Future," the first part of which was published in the November Monthly, under the title of "Education as a Hindrance to Manual Occupations."

elements of certain handicraft industries. Overlooking the extreme diversity of type that exists among such schools, we have been apt mentally to throw them all together, and to refer to the supposed system on which they proceed as "the Continental system," in contradistinction to our British system of training, as we are pleased to term our obsolescent institution of apprenticeship proper. Nothing could be more misleading than this classification. It arises from lack of information as to the nature and work of such schools. It is not surprising, when such ignorance prevails, that the fallacy has in consequence been widely spread that the long undisputed superiority of British-made goods was due to the superiority of the British system. On the contrary, that superiority, which arose out of quite other economic causes, was the very thing which stirred up the Germans, Swiss, Belgians, and French to devise schemes for training workmen more efficiently and intelligently than was done in England, since only by such means could they hope to compete with her industries. Let the significant fact, that a very large proportion of the foremen of workshops in our skilled industries are Germans or Belgians, attest the result of a higher technical training. Besides the innumerable *Gewerb-schulen* and *Real-schulen* of Germany, where a general preparatory scientific and technical education is given, that empire can now produce a long array of trade-schools, sometimes organized as polytechnic schools, and sometimes devoted to particular trades, such as weaving, dyeing, or carpentry. In Switzerland such schools also abound; and in the commercial centers of Belgium they exhibit an extensive and healthy development. In France there are the technical schools of Douai, Chalons, and Aix, the École la Martinière of Lyons, the Horological School of Besançon, the Apprenticeship School of Havre, where workers in wood and iron are trained, and twenty others, including five or six in or near Paris. The technical schools of Paris present, indeed, so much diversity in their several organizations and results that it would be extremely difficult, even by going over a much wider area, to find so many different yet thoroughly characteristic types. To understand how completely different are the systems of organization by which it has been sought to solve this great problem, it would be necessary to pass from the Polytechnicum of Zurich—the Technical *University, par excellence*—to the Horological School of Besançon, and from the *Kunst-gewerbschulen* of Munich and Nuremberg to the unrivaled Pedagogic School of Moscow, and even then the list of types would be less complete than that which is afforded by the schools of Paris. In that great capital, in addition to the École des Arts et Métiers, the École des Mines, and the École Centrale des Arts et Manufactures, whose portals open only to an older and better educated class of students, and the great schools of modern type, such as the École Turgot, the Collége Chaptal, and the École Commerciale in the Avénue Trudaine, which qualify their pupils for commercial and mercantile careers,

there are a group of technical schools intended for those whose primary education is not yet, or only just completed, and in which not only theoretical technical instruction is given, but where systematic instruction in some useful handicraft forms a necessary feature. From among these diverse types we select four, for each one of which its promoters claim that its practical success solves the knotty problem of the day. These four schools are the *École Communale*, in the Rue Tournefort; the *Institution de Saint Nicolas*, in the Rue de Vaugirard; the *École Professionelle*, established by MM. Chaix et Cie. in their printing establishment in the Rue Bergère; and the *École Municipale d'Apprentis*, in the Boulevard de la Villette.

The first two of these may be said to exemplify, though with striking diversity of method, *l'atelier dans l'école*, the workshop in the school; the third is an excellent instance of the school in the workshop; while the fourth belongs strictly to neither type.

The *École Communale*, situated in the Rue Tournefort, a crooked back slum behind the Panthéon, is the most recent of the group which we have selected. Founded in November, 1873, at the instance of M. Salicis, and with the coöperation of M. Gréard, the energetic Director of Primary Education for the Department of the Seine, it is intended rather to prepare for than to supplant apprenticeships of a more rigorous type. The pupils of this school are not apprenticed at all in the ordinary sense; there is no contract, and they earn nothing. Most of them are very young—even as young as eight or nine years—nor have they yet completed their elementary education. If they stay out the prescribed three years' course, they not only get as good a schooling as in any of the ordinary elementary schools, but they will also have seen something of constructive industry. During the first two years they are sent to work *for a day at a time*, in rotation, in one or other of the occupations of the workshop. An "apprentice" will thus have one day in the carpenter's shop at the bench or the lathe; the next he will be learning how to forge a bolt; the next he will devote to metal-turning—all his exercises being directed by practical workmen in charge of the shops. During the third year he will settle down to some one pursuit. The hours of actual labor are short, for the chief part of the day is devoted to lessons, only an hour and a half each morning and afternoon being given to manual labor. All learn drawing and modeling. Every pupil works from drawings which he has previously made to scale: no matter what he does, whether he is making a mortice-joint, rabbeting a window-frame, or filing down an iron nut, it is always done according to a careful sketch made beforehand. No articles whatever are made for sale; indeed, all commercial elements are scrupulously avoided, and the objects given as exercises are hardly such as would serve a useful purpose: little joints of wood accurately squared; little cones or cylinders turned with perfect truth of line. Here and there a more valuable article, a model of a crane in metal, or a model

system of beveled gearing-wheels ; but nothing more marketable. The genial director, M. Laubier, enters heartily into the work of his pupils. He has himself designed and executed many of their exercises—the plaster casts, the geometrical models, and the ingenious scholastic appliances of the institution. He thinks his school to be the type of the elementary school of the future. He has need to be an enthusiast, to train successfully his fifty apprentices and his two hundred non-working children on a grant not exceeding sixteen hundred dollars a year, salaries, tools, and materials included. He upholds the rotation system, believing extreme division of labor to be at this stage prejudicial to the development of the youthful faculties. He does not want to sell the produce of his workshops, as the construction of objects which would be made to sell would not afford so good a training for his boys. He admits that they do not work so rapidly as apprentices who have been brought up amid the hourly exigencies of trade ; but he adds that he prefers cultivating their intelligence to quickening mere manual dexterity ; that will come later. And what are the results? "Our apprentices," says the director, "being at once fit for useful work on entering the factory, are less often employed to run errands ; they are better treated, steadier. I could tell you of young lads of fifteen who are actually earning two francs and a half, and two francs seventy-five centimes a day, and who in six months more will be paid as regular workmen."

The *Institution de Saint Nicolas*, in the Rue de Vaugirard, is the oldest of the schools, having been founded in 1827. It is under the exclusive management of a religious guild known as the *Frères des Écoles Chrétiennes*, who devote themselves entirely to education. In this truly remarkable establishment there are eight hundred and ninety boys, all children of artisans, all boarders. Of this number, about two hundred are apprentices who come here to learn their trade. None are admitted who can not already read and write. The greater part of the day is given up to manual work, only two hours being reserved for schooling on three days of the week, on the alternate three days the two hours are devoted to drawing. On entering the premises the visitor is first introduced into a sort of little museum, in which are exhibited articles made by the pupils of the establishment—a truly surprising collection to have been executed by little fellows from eleven to fifteen or sixteen years of age. Here there are picture-frames, bronzes, panels carved in oak, wood-engravings that would not discredit either the "Graphic" or the "Illustrated" ; farther on, in another handsome case, are telescopes, leveling instruments, a model engine, a saxhorn, and a trombone ; and, in yet another, some exquisitely neat engraved maps, some of them executed on commission for the Government, together with the medals they won in Paris, Vienna, and Philadelphia. A varied assortment it would seem, and indeed the system under which such works are produced is without a parallel

in this country. There are in the extensive premises of the school no fewer than sixteen *ateliers*, each let out to an approved master or *patron*, who is usually also the proprietor of a separate business in the city. To him are apprenticed for a term of three, or in some cases four, years some ten or twelve boys, all of whom at the end of that time will be able to take good positions as intelligent workmen. The trades thus taught are those of carpenter, wood-carver, turner in wood, optical turner, compositor, printer, wood-engraver, map-engraver (on stone), marble-mason, brass-worker, bookbinder, carver and gilder, clock-maker, portmanteau-maker, philosophical-instrument maker, and maker of wind instruments. The master of each separate *atelier* provides the materials, devises the work of the apprentices, superintends its execution either personally or by an authorized *contre-maître*, and to him belong the products of the workshop. Nothing is made in the shops that will not sell ; the apprentices learn the value not only of materials but of time ; and, though the works that successfully pass under their hands are graduated to their capacity and experience, they are precisely of the same character as those which apprentices in any ordinary workshop would have to undertake. The masters and foremen of the various *ateliers* appear to take great interest in their pupils, and pride themselves on the success of their instruction. "These boys," said the foreman of the portmanteau-makers, "when they leave this room know the whole mystery of their trade from end to end. They can take the *brute* materials, and from them evolve a finished article." The apprentices of this same shop will earn at once from five to six francs a day, instead of the two, three, or four francs usually earned by young workmen just out of their time. They work as quickly as other workmen, for they know from the exigencies of their particular work that time is money. Several of the *patrons* and foremen of the little workshops are themselves former pupils of the establishment. The apprentices earn nothing during their term of service beyond a little pocket-money when they are satisfactorily advanced. During the whole period of their apprenticeship their parents must contribute thirty francs a month for their board and lodging in the school. Great importance is attached by the *Frères* to the complete isolation from exterior influences insured by this internment. The magnitude of the work will be understood when it is learned that the income and expenditure of this establishment amounted to about two hundred and thirty thousand dollars in the past year, the services of the fifty worthy *Frères* who conduct the school being given at a purely nominal rate. There is a large gallery in the building for drawing and modeling, and excellent systems of instruction in model drawing and geometrical drawing have been here developed. Spacious refectories, commodious well-ventilated dormitories, and a large gymnasium form features of the school. The results of the system are significant. The aim of making intelligent workmen is really attained, and though the

pupils have learned but one *métier*, and are in general better adapted for small businesses than for large, their repute for steadiness, skill, and general intelligence is such that the *patrons* have little difficulty in placing their pupils when their term of apprenticeship is over, and usually in circumstances where their earnings are about the average. The same testimony is borne everywhere concerning the apprentices of this establishment; and the writer was informed by M. Véver, President of the Syndical Chamber of Jewelers, of Paris, a gentleman greatly interested in the question of technical education, and possessing every opportunity of forming an accurate opinion, that the boys of Saint Nicolas are so much more intelligent and steady than the average of workmen that they are sought for by employers, and at the age of thirty have usually risen to the position of foreman or master.

The third type of apprenticeship school is that of the *École Professionelle* attached to the large and flourishing printing establishment of MM. Chaix et Cie. This school, founded in 1862 by M. Napoleon Chaix, receives two groups of pupils, the apprenticed compositors and the apprenticed printers of the house. The schoolroom and the apprentices' composing-room, though contiguous to and overlooking the great busy *atelier* of the firm, are distinctly separate from it. The apprentices, of whom there are between thirty and forty, devote most of their time to the practical work of composing, two hours a day only being allotted to lessons in the schoolroom. Apprenticeship lasts four years, during the whole of which time the apprentices receive wages rising from fifty centimes to two francs fifty centimes for the compositors; and for the printers, who work at the machines in the great *atelier* under the direction of a responsible master, from seventy-five centimes to four francs fifty centimes a day. The teaching comprises a special primary course for those whose previous schooling has been insufficient; a technical course, including grammar and composition, reading of proofs and correcting for the press, the study of different kinds of types, engraving, and the reading and "composing" of English, German, Latin, and Greek—in the two latter cases from a purely typographical point of view, without any attempt to understand or to translate; lastly, a supplementary course which includes the history of printing, simple notions of economics, a little mechanics and physics, and a smattering of chemistry, dealing chiefly with the materials that they will hereafter employ—acids, oils, fats, carbon, soda, turpentine, etc. Everything is done with the utmost system. Every line set up by a pupil is, if possible, so much contributed to the current work of the firm; and, as time exercises are frequent, the value of rapidity in work is learned. At the end of the apprenticeship the pupils elect—almost without exception—to become employees of the firm, and enter at once into the rank of participants in the yearly division of profits. Of nearly seven hundred persons employed, two hundred and fifty-eight

are now participants, of whom about eighty are past apprentices. A much larger portion are depositors in the *caisse d'épargne*, or savings bank, established by the firm, or are "insured" in its books. Even the youngest apprentices put by a portion of savings out of their small earnings. The principals of the house fear no strike now, as there are enough participants in the wealth of the house to carry on its business through a crisis. "*La maison pour chacun, tous pour la maison*," is inscribed in gold on one of the beams that cross the great *atelier.* The sum thus divided among the employees in 1878 exceeded ten thousand dollars. The financial results of these arrangements, at once educational and prudential in their nature, are most encouraging. M. Berger, the accomplished inspector of this department of the enterprise, attributes the substantial growth and prosperity of the business, now one of the largest and wealthiest in France, as much to one influence as to the other. He prides himself on the superior intelligence of his pupils and their technical knowledge, gained while they are in the very midst of a great business, and thus forced even to realize and keep *au courant* with commercial exigencies. The few who have gone out to take places elsewhere are also doing well.

The fourth and last of our typical schools is the École Municipale d'Apprentis, which since 1872 has been at work in the Boulevard de la Villette. No school has produced more striking results as yet, and none merits more careful attention. Beginning with seventeen pupils in 1872, it now numbers a following of two hundred and twenty-one. The course lasts three, or in some cases four, years. It speaks volumes for the efficiency of the school that, out of seventy-two who, up to the end of 1877, had completed the course and gone out into situations, sixty-nine are at the present moment pursuing the trade they have learned in the school, and are earning on the average four francs a day—some of them even as much as six and a half francs a day. A school which can receive young lads of thirteen or fourteen, and after a three years' course can turn out workmen at the age of sixteen or seventeen able at once to command wages of twenty, or, in some cases, thirty-three shillings a week, is something so wholly new that its organization merits the most profound study. Founded on the suggestion of M. Gréard by the then Prefect of the Seine, M. Léon Say, at the expense of the city of Paris, it began its work in premises previously used as a factory of aneroid barometers, additional schoolroom accommodation being obtained in the adjacent dwelling-house. The object of the school is simply to make *good workmen.* The education it offers is absolutely gratuitous, and even remunerative to the pupils, for they receive every week a "gratification" varying from a franc and a half to three francs. None of the pupils are boarders. None are admitted until their primary education is completed, and then only after an easy examination. Five hours a day are given to studies, six hours to the work of the shops. The teaching of the schoolroom is both general and technical

in character, mechanics, physics, chemistry, and technology being added to the usual programme of literary routine, while drawing and modeling occupy a prominent place. The system of solid geometry taught in the schools is excellently conceived and admirably followed. M. Müller, the director, himself conducts this and some of the scientific branches of study. All the apprentices learn also to sketch bits of machinery or even entire machines, figure the sketch from actual measurement, and then with rule and compass draw them carefully to scale. There are two principal workshops, one devoted to the workers in iron, the other to workers in wood. The trades actually taught are forging, metal-turning, fitting, carpentry, wood-turning, and pattern-making. A small workshop for teaching the manufacture of philosophical instruments has also just been organized. During his first or preparatory year the apprentice, so called—there is, in reality, no formal contract—is making the round of the various shops, taking a fortnight in each in rotation. There is therefore no haste to specialize his work, and he has the opportunity of discovering the pursuit for which he is best fitted, while gaining information and intelligence. His first year over, he settles down to serious work in one of the six categories of labor: henceforth all the articles he makes are salable, and indeed of some value. Still, although the commercial element, eschewed in the Rue Tournefort, here steps in—to the profit of the municipality, be it said, rather than of the school—the apprentice does not sacrifice theory for practice. No single object must be attempted before the working drawing of it has been made out in plan and elevation; and the niceties of true surfaces and exact angles are scrupulously insisted on. Enter the forging and fitting shop, where over a hundred embryo workmen are busily, not to say noisily, employed, each on his all-absorbing task: they hardly look up as the stranger passes along. Here are three novices being taught to forge a hammer-head, learning to "strike," under the direction of a young foreman; and he *does* teach them, too, with a will. Here an older group are working out a piece by themselves at another forge. All down the long room are benches with vises, and in the middle the heavier machines, lathes, slotting-machines, and planing-machines—the latter designed and constructed only last year by the pupils themselves, and containing a valuable improvement first conceived in the brain of the able foreman of the workshops. Here, a large pinion is being turned; there, the parts of a vise are being filed into shape, while in the corner an apprentice of one week's standing is trying to file up into perfect form a simple square bar of iron fresh from the forge. After that he will pass to a task a little more difficult, following the course prescribed by experience. Almost all the tools are made by the apprentices themselves. The steam-engine which moves the heavy machines is under the charge of two pupils, of the second and third year respectively, their services being devoted for a fortnight to officiating as stoker and engineer. Healthy

and actively industrious the lads toil at their work, and three foremen suffice for the efficient superintendence of the hundred! Above is the carpenter's shop, where an equally numerous *clientèle* are equally hard at work. Here, too, we find originality of design and thoroughness of execution. Several of the machines—for example, a ribbon-saw—were made in the establishment, and were among exhibits of the school which attracted so much notice in the central pavilion of the Exposition Universelle of 1878. The first exercises in carpentry and in turning are literally exercises; useful to the last degree to their constructor, but of no marketable value. Here one realizes one advantage possessed by this municipal school over those in which the *atelier* is simply the workshop of a great business. In the early stages, when workmanship is very imperfect, it is not always well to strive to produce a salable article. Better waste wood, says the superintendent of the shops, than spoil the making of a good apprentice. Better to let the young workman see something of all the different corners of his trade, than by too fine a division of labor to keep him all his years learning only to shape chair-legs. And he is right, if the general look of intelligence and workmanlike style of his young charges afford any indication of their capability of well fulfilling the career they have chosen. From seven in the morning to seven in the evening are the hours of school, with an hour's intermission for dinner, and two shorter recesses. Work over, they disperse to their separate homes, for there is no boarding. M. Müller points out that the cost of setting up these shops, with all their tools and appliances, has been at the average rate of $55.75 for each of the one hundred and seventy-five places nominally provided in the accommodation of the school; while each of the present two hundred and twenty-one pupils, as he passes through the school, costs the municipality on the average an annual sum which is, as it happens, almost equal, namely, $55.50, instruction included. When the extensions of the buildings now in progress are completed, a very slight increase of total cost will suffice to extend the benefits of the school to a much greater number of pupils. The school property and furniture have already cost the city of Paris 750,000 francs ($150,000), including the lands and buildings, and the school is costing it 60,000 francs ($12,000) a year for working expenses. To set against this are the sums received for work sold, and the value of the instruments, models, and appliances fabricated in the school, and employed either in the school itself or handed over to one or other of the municipal schools, and which must amount to many hundred dollars yearly.

We have dwelt at some length upon this school, inasmuch as, regarded from the point of view of practical results, it appears to present by far the nearest approach to the ideal of an apprenticeship school. Not ignoring what is so valuable in consideration of the circumstance that the training is to be a preparation for after-life—the commercial value of the time and labor—it differs from the Institution

de Saint Nicolas in regarding the aim of producing good workmen as higher than that of establishing a self-supporting school. The Institution de Saint Nicolas is, thanks to the self-denying labors of the *Frères*, self-supporting so far as the *ateliers* are concerned, though the pupils pay for their board and lodging. The École Professionelle of MM. Chaix et Cie., which is but one example of a considerable number of similar establishments, is looked upon as one of the main causes of the prosperity of the concern. To establish such a school in any large business establishment requires little additional expense beyond the salaries of teachers. The École Communale is a most valuable experiment, and shows with what slender outlay some useful instruction in manual labor can be added to the resources of an elementary school. The École Municipale, with its kindred schools at Lyons and Havre, enable us to realize what an apprenticeship school may become if taken in hand by a rich and powerful municipality.

Turning once more to the conditions which obtain in our own country, the thought naturally occurs, Which of these very different types of school will best suit the requirements at home? On which line shall we proceed in our attempt to adjust to the altered social and industrial conditions of our time the apprenticeship of the past? Probably no one of these varied types will meet the thousand possible cases which may present themselves in the working out of the problem. Possibly there is room for all these types of apprenticeship school, side by side, or room even for new and untried types. One may adapt itself better to one locality or industry, another to another. Our business is not to copy, but to create and to develop for ourselves that which meets our own case. Much as will depend upon the character of each individual industry, all experience shows that there are other factors in the problem of scarcely less importance, and that much also depends upon the individual proclivities of the director of the school, the industrial enterprise of large firms, the far-sightedness of wealthy corporations. In France many of the schools have been initiated by the municipal or communal authorities. In Germany it is the town or the state that has made the venture. Will our town councils or our school boards ever think the experiment worth a trial, or is centralization too fierce and too frigid to countenance the attempt? All that is most valuable in the results obtained in the majority of the typical cases afforded by the Parisian schools can also be attained by private local enterprise, if guided wisely and well. Private local enterprise may surely hope for a success at least as great at home as that which it has already won across the Channel. And obviously the various industrial establishments know best the strength and weakness of their own resources. If a guiding and organizing central institution is needed, and it probably will be, it will be forthcoming so soon as there is work for it to do. But no central organization or institution can be expected to do the work which, at the outset, the local in-

dustries must initiate for themselves and develop by their own resources, and direct by the light of the consciousness of their distinctive needs. Then, and not till then, shall we able to form an exact estimate of the social and industrial conditions under which *the apprenticeship of the future* may become a living reality. Then, and not till then, will the apprenticeship of the future constitute a powerful instrument, not merely for the intellectual, moral, and social improvement of the working-classes, but for the promotion of the wealth and prosperity of the whole nation.

THE MIGRATIONS OF FISHES.

By Dr. FRIEDRICH HEINCKE.

THE periodical migrations of birds, grand as is the scale on which they are performed, and fitted as they are to excite astonishment, are insignificant compared with those which are made by the fishes of the sea. A faint illustration of the stupendous character of these movements is given off the west coast of Norway at the opening of the fishing-season in the spring, when one, looking out over the sea in quiet weather, will be witness of a stirring spectacle. The surface of the water as far as the eye can reach glistens in diversified colors ; the fiords and bays are alive with silvery streaks playing in constant movement. The agitation is caused by the schools of herring, which are so closely packed that a boat can not pass through them, an oar may be made to stand up among them, and they may be dipped up in buckets or caught with the hand by the thousand. The enemies of the herring also come with them—the mackerel, the sharks, and the dolphins enlivening the scene with their graceful movements, with great flocks of gulls. The sprat also appear in great multitudes on the coasts of the North Sea, and the pilchards on the coasts of France and Spain and the southwestern coasts of Great Britain in such immense schools that millions of them have been taken with a single draught of a large net.

The fish of the family of the *Gadidæ* regularly visit the northern seas in innumerable hosts. The codfish come between January and March to the shallow bays of the Loffoden Islands and the banks of Newfoundland, where their fishery gives employment to more than ten thousand vessels and about one hundred and fifty thousand fishermen.

Codfish and herring belong entirely to the sea. Many other fish wander from the sea into the rivers. The sturgeon and the white-fish go from the Caspian Sea to the Volga to spawn in such numbers that, before the fishery became so destructive to them as it is, the children on the shore could scoop them up with their hands. Still more remark-

able are the schools of fish of the salmon family that resort to the great rivers of Siberia after the breaking up of the ice.

The resort of the fish to the same place is repeated every year with a wonderful regularity. The appearance of the herring in Norway varies at most not more than fourteen days. The energy of the movements is remarkable. The salmon, traveling from the sea to its spawning-places, surmounts considerable difficulties, leaping up to the tops of falls several feet high, and repeating its jumps if it fails at first, till it succeeds. Eels are able to ascend waterfalls forty or fifty feet high, and it has been asserted that they have been known to climb the falls of the Rhine at Schaffhausen; and since the sluices have been put down they have been able to pass the six falls of the Trollhätta, which have together a height of a hundred feet.

Fish travel to very considerable distances in these journeys. Brehm estimates that the salmon of the Obi and Irtish travel about 7,000 kilometres (4,340 miles) a year up and down the stream; and salmon and sturgeon often go from 1,500 to 2,400 kilometres (930 to 1,500 miles) from the sea to their spawning-places, and salmon to a height of 2,000 feet above the level of the sea. Salmon may occupy six or eight months in going up the stream and accomplishing their spawning, but will return to the sea in one or two months, traveling from ten to thirty kilometres ($6\frac{1}{4}$ to $18\frac{3}{4}$ miles) a day.

Fish, like birds, return from the most distant journeys to the places of their nativity. This has been ascertained by marking individuals and watching for their return. This faculty of localization bespeaks a higher degree of intelligence than we have been accustomed to ascribe to fish.

The theories that have been proposed to account for these migrations have failed to give a fully satisfactory explanation of them. The migrations as a whole may be considered under five heads, of which the first and most important comprises the journeys to the places of spawning. The most notable instances of such excursions are those of the salmon tribe, and of the sturgeon, lampreys, eels, and tunnies. The proper home of all these fish, except the eel, is the sea; and, besides the eel, all of them except the tunny make yearly considerable journeys up the rivers to find places suited to the development of their spawn. Such places are, for the sturgeons, about the middle of the course of the river, in shallow, sandy spots; for the salmon kind, among the hills near the sources, or in the fountain-streams themselves, where the water runs in a lively current over a stony or gravelly bed. The lampreys ascend about as far as the sturgeons. Their young, which are very different in appearance from the parents, may be found in great numbers in nearly all the still brooks and ditches of the middle parts of the river-courses. The eel is the only European fish which goes from fresh water to the sea to spawn. Its journeys take place some time before the fish are ready to spawn, an abode in

the sea seeming to be essential to the ripening of the ova—a property which makes the study of the procreative functions of this fish more difficult. The tunny lives exclusively in the sea, but goes to the coasts of the Mediterranean, particularly to Sicily and Sardinia, to spawn. The sea graylings ascend the rivers of Spain and France in such numbers that the water seems covered with them.

The journeys of the fish in returning from their spawning-places after spawning are seldom performed in masses, but individually and in small groups. The fish, which went up fat and in fine condition and flavor, are exhausted, lean, and weak. Not much is known of the migrations of other fish than the salmon during these journeys, for the fishermen pay little attention to them and they therefore seldom come under the observation of science.

Next in order of the migrations are those of the young brood from their spawning-places. The young herring do not as a rule remain longer than four or five months where they are hatched. They then go down to the sea while the young eels go from the sea up to the rivers after about the same time. The young herring are observed with difficulty, for it requires a skilled eye to perceive their minute, transparent bodies in water that is in any degree disturbed; but in perfectly still water the schools may be seen moving to and fro like fine flecks of cloud. The salmon remain a full year in the mountain-streams, and do not go down to the sea till they have become a vigorous, greedy fish of about a finger's length.

Journeys in search of food are not periodical or regular, like the previous migrations, or are only incidentally so. The most important of them and the nearest to being periodical are the visits of the codfish to Newfoundland and the Loffoden Islands, concerning which it is as yet not certain whether they may not be partly connected with purposes of reproduction. Schools of other smaller fishes appear along with the cod, a salmonid, the herring, and a number of squids, which are all alike used by the fisherman as bait. The migrations of the predatory fish which follow the other fish in their spawning-journeys naturally partake of the periodical character of those journeys; the fish that pursue the herring follow them into the farthermost corners of the bays to which they resort.

The autumnal visits of mackerel to the Gulf of Kiel are of particular interest. They do not take place every year, and are not often marked by very great numbers, but they have attracted attention since 1624, when they were described by Schonevelde, on account of the peculiar character of the food that attracts the fish. The Gulf of Kiel is visited in August and September by great numbers of the *Medusa aurita*, which fill its waters, perform their reproductive duties, and perish on its shores, leaving hardly a trace of their watery tissues behind. In their maws swarm numerous individuals of a moderately large parasitic crab, and it is for the sake of these that the mackerel

throng in the bay, attack the Medusæ, and consume them. Mackerel feed upon minute crustaceans, chiefly copepods, which swarm on the surface of the water and often cover it, and follow them hither and thither as they are carried about by the currents.

The number of fish which lead an irregular vagabond life is not inconsiderable. Foremost among them are the sharks, which singly or in small companies will follow a ship for days at a time in order to snap up whatever may be thrown overboard from it. They are often accompanied by the pilot-fish, which has a peculiarly strong sense for food of all kinds, and directs the shark, is protected by him, and gets a share of the spoil. Other formidable fish, unsocial in their habits, being scattered over the ocean, are less accessible to science.

When more than the usual number of fish go up to spawn, the number of fish pursuing them is likely to be also increased. It sometimes happens thus, that species of fish which have not commonly followed the schools are attracted to them by the extraordinary abundance of food, and find their way to places where they were before unknown. Many fish are found in opposite quarters of the globe. The *Trachurus trachurus*, of the mackerel family, inhabits South American and Australasian as well as British waters. The sprat, common in the North European seas, has been discovered near the coasts of Tasmania, and thus lives at diametrically opposite points, while it has never been observed in the intervening seas. Inasmuch as migrations may often lead to a permanent enlargement of the domain of certain species, a knowledge of the laws and circumstances by which they are influenced has an important bearing on the study of the geographical distribution of species.

Migrations may also be performed under the influence of circumstances not connected with reproduction or the search for food. It is not certain whether fish are ever driven from their homes by a cooling of the water. Removals from such a cause would not take place in large masses, and might easily escape observation. As a rule, fish are not sensitive to changes of temperature, and can endure the greatest diversities provided they have food enough. Certain tropical fishes have a remarkable faculty of performing journeys by land. The climbing fish and an *ophiocephalus* of the East Indies and the *Doras costatus* of South America are able, when the ponds and swamps in which they live are dried up, to travel for several hours over the land to find places affording more water. The eel has been said to travel for considerable distances from one pond to another. It is certain that eels are able to live for a considerable time out of the water, and, though the fact has not been scientifically established, there is no reason to doubt that they can travel. The stickleback is often found in pools wholly unconnected with other waters. It may be that the eggs of the fish have been carried on the feet of waterfowl, or that the wanderers have found their way to such places during the rains of

the spring and fall, when the fields, the ditches, and even the wagon-tracks are running with water. Fish often remove from their abodes under the influence of circumstances unfavorable to their existence. If there is an unusual abundance of their food in one year, the number of fish will be greatly increased, to die of starvation as soon as the food is consumed. They are also often driven out in consequence of the pollution of the rivers, either dying or going to other places where the waters are more favorable to them. Whole communities in Norway and Sweden have been ruined by the sudden and unaccountable disappearance from their shores of the herring, on the catch of which they depended. In such cases the fish have sometimes absented themselves from their former haunts for a hundred years or more, while fishermen and students have endeavored without success to discover the causes for the change.

The conditions of a scientific explanation of the migrations of fish are not satisfied when we say that they take place in search of food or with the purpose of reproduction. We have still to ask what are the conditions connected with these objects which make necessary such extensive journeys. The answer is easy in cases where food is the object of the journey. The fish go where they can find the food that suits them. But why does the herring go to the shallows of the coast instead of leaving its eggs in the deep sea? Why does the salmon leave the ocean and go away up to the sources of the rivers? Experience gained in the artificial propagation of fish has partly helped to answer these questions. One of the most essential requisites to a good hatch of the eggs is a plentiful supply and free circulation of air. Hence it is necessary for the eggs to be laid in well-ventilated waters. This is impossible if they are spawned in deep water, where they will sink away below the reach of atmospheric movements. They must be deposited in waters that are disturbed to the bottom. Such waters are the shallows near the shore, where the herring lay their eggs, and the living streams, which are the resorts of the salmon and sturgeon. The fish, impelled at spawning-time to go in the direction of the most air, keep on till they find it in the places best suited for breeding. Different species of fish require different amounts of oxygen, the same as different animals do. The salmon and trout need much, and for it seek those waters which have the liveliest motion—mountain-streams. The opinion that these waters are more favorable to the development of the eggs because they are fresh is based on erroneous premises. Many of the species that commonly go to fresh waters also lay their eggs in salt waters, and even salmon sometimes lay them in the sea. Salt water really appears, from the most recent researches, to contain—other conditions being the same—more air than fresh. The same cause which impels the salmon to ascend to the lively, fully aërated streams of the mountains attracts other fishes from the deep seas to the shallows and rivers, and the eel from the bottoms of still-water

ponds to the wind-disturbed waters of the bays. Those fresh-water fishes that do not wander away, go to the well-aired spots in their neighborhood to spawn—to the shore-waters, the wet meadows, or the junctions of rivers, or to the tributary streams of the lakes in which they live. Those salt-water fish which live at the bottom likewise go to the waters near the shores, where the flats and the meadows swarm during the spring with their young. The eggs of the cod and mackerel are buoyed upon the surface of the water, where the winds blow constantly over them. The stickleback will swim before its nest and fan it with its pectoral fins by the hour. Thus every fish illustrates in some way the law that a constant change of air is essential to the development of its eggs. Agitated and sun-lighted waters are also most favorable to the larvæ of crustaceans and mollusks, of echini and polyps, and to the microscopic creatures of which the food of the fry chiefly consists, and thus fulfill another condition of the most vigorous growth of the young fish.—*Translated and abridged from Die Natur.*

DOMESTIC MOTORS.

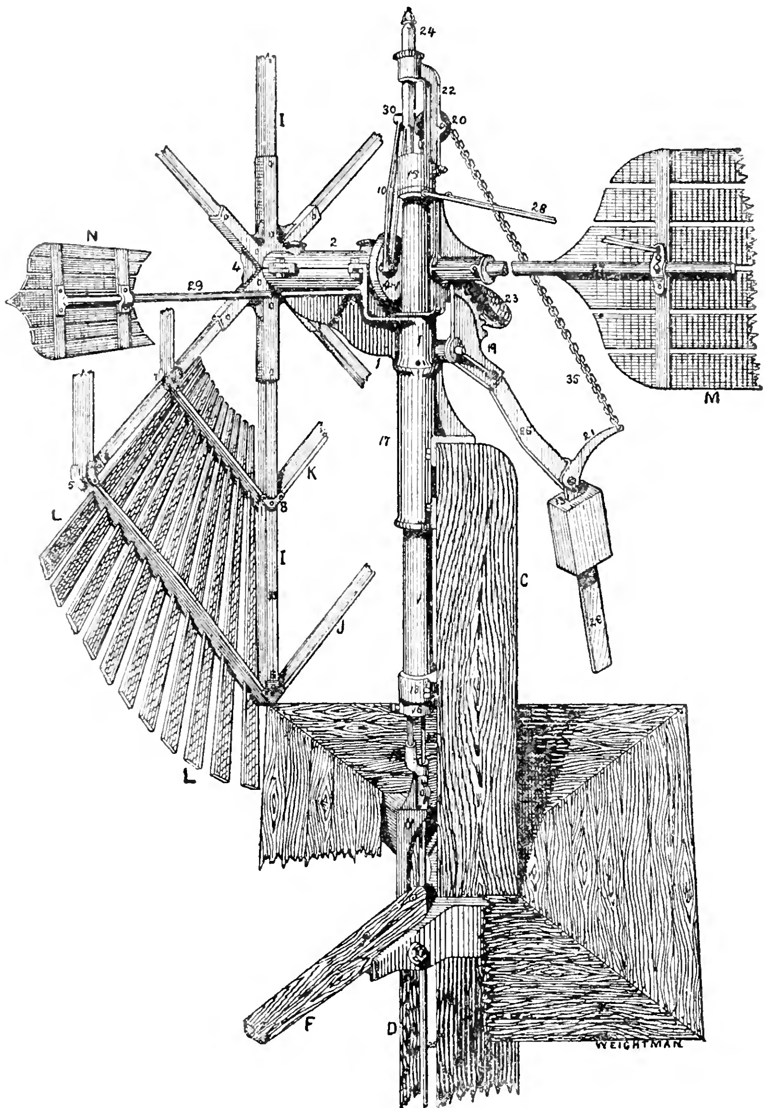
By CHARLES M. LUNGREN.

I.—WIND AND WATER POWER.

THE situations in which a motor of comparatively small power can be used with advantage, and in which it is a necessity even, are already very numerous and are constantly increasing. Not only has it a proper place in the workshop, in the business house, and on the farm, but in the household as well it has a wide range of utility. The need for such a machine in our homes, created by the sewing-machine, has been strengthened and increased by various other appliances in use or coming into use, while such devices as fans for cooling rooms in summer and ventilating them in winter further add to the requirement. In suburban and country residences, and on the farm, the primary need is for pumping water, and this alone renders a light and economical power almost indispensable. For the performance of most of the other mechanical operations upon the latter it is also of the utmost value. In the field of small industries the uses to which such a motor can be turned are as numerous as the varied occupations of the workers. The necessities of numbers of amateurs further increase the range of activity for such a power. The kind of machine that is suitable to the varied needs of these different classes of users necessarily differs in each. In most trades the demand for power is for one of from two to five horse and above, and on the farm a serviceable machine could not generally be much if any less; but in the

household that desired is rarely above one horse, and generally under it. A more complicated machine can, moreover, be used with success in the workshop than in the household, as in the latter it would gen-

Fig. 1.



erally be in the care of attendants but little, if any, skilled in the use of machinery. Certain general conditions are, however, common to all. The work for which it is needed is generally of an intermittent

character, and this necessitates a machine that will always be ready for work, or that can be made ready with but little trouble at short notice, and that is no expense, or but very small expense, when not being used. It needs further to be perfectly safe, economical in use, of low first cost, and to require but little care, and that of a kind which can be given by unskilled labor.

The attempts to make a machine that would answer to these varied requirements have been many, and they have been crowned with greater or less success. Though it can not be said that the ideal motor has been produced, still there are at present made and on the market a number of machines of real merit, and some of great excellence, that are all well adapted to the needs of users of light power, including the householder. While in large manufacturing only two machines—the water-wheel and the steam-engine—can be used, for the purpose of these small powers the range is much greater. Wind and water, steam, hot air, gas, and electricity, are all suitable and are all to a greater or less degree available. I propose in these papers simply to make a brief description of some of the more promising and successful machines now on the market, and give such information regarding the sizes in which they are made, cost of working, and prices, as will be of value to the householder and others having use for such a power.

Though the windmill is one of the oldest of the appliances by which man has sought to turn to his use the powers of nature, it remained until a comparatively recent period a very crude and cumbersome machine. In the earliest form, the wheel was fixed so that it could only turn when the wind was in the right direction ; and later, when it was made movable, the shifting had still to be done by hand as often as the wind veered. Successive improvements were, however, slowly made, the chief ones being the addition of a rudder-vane placed directly behind the wheel in a vertical plane at right angles with its face, and a centrifugal governing device by which the canvas sails were furled and unfurled as the wind varied in strength. The pressure of the wind upon this vane automatically shifted the wheel into the wind, and the action of the governor presented to it a greater or less surface of the sails, securing a uniform velocity with varying wind-pressure. Even with these great improvements the windmill remained a clumsy affair until it was developed by American skill and ingenuity into the present very serviceable machine. As now made it is light and strong, and entirely automatic in answering to the varying direction and pressure of the wind. The canvas sails have given place to light wooden slats arranged radially around the wheel at short distances apart, and the whole mechanism has been simplified and vastly improved both in construction and design. The tower is an open-work structure of wood or iron, easily erected and taken down when desired.

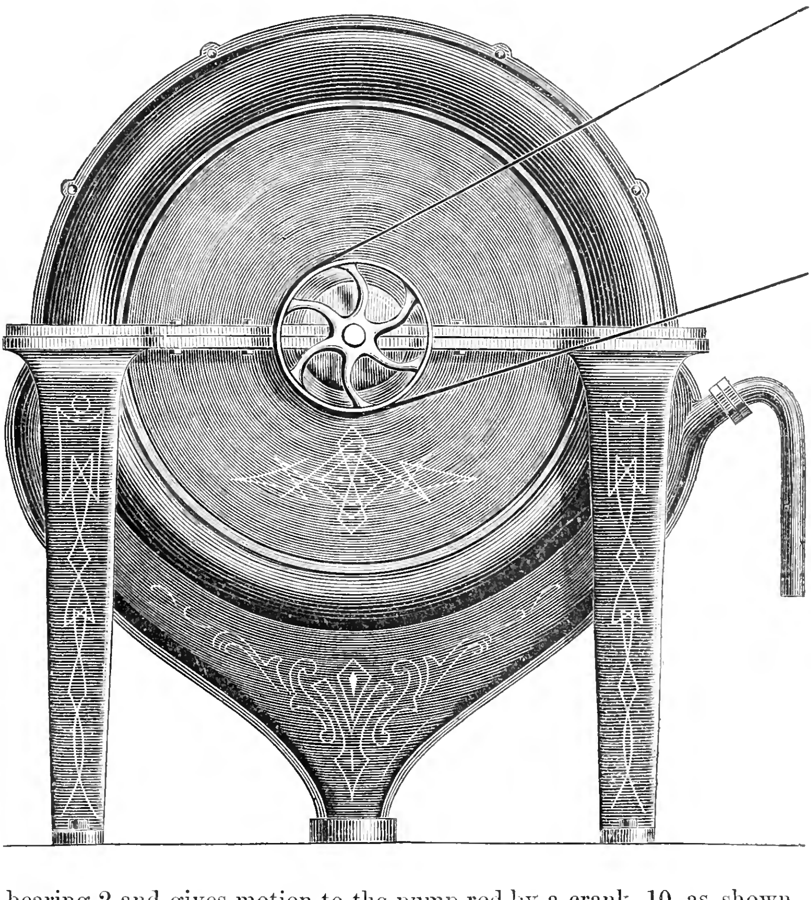
Two methods of regulating the extent of wheel-surface exposed to the wind are now in use, the one acting by centrifugal force as in Eu-

ropean mills, and the other by the direct pressure of the wind against a side-vane. In centrifugal mills the wind-wheel consists of a number of radial arms firmly secured in a metal hub, with sections between them pivoted so that they can swing into a position in which the ends of the slats only are exposed to the wind. They are held in the plane of the wheel by a counterweight, and thrown out of this position by the action of a ball-governor. This governor may be placed in various positions on the wheel, and act upon the movable section directly or through the medium of connecting rods. In one form of wheel the balls are placed upon the framing so that when the wheel is at rest they hang down upon its face, but as it revolves fly out, and in doing so turn the sectors. The angle at which the wheel-surface is exposed to the wind is thus altered with every variation in its velocity, and the motion of the wheel consequently kept nearly uniform, in a manner similar to that of a steam-engine. When the wind attains a velocity greater than a certain number of miles an hour, the action of the governor keeps the slats in the position in which their ends are alone exposed to the wind. The velocity at which the wheel will completely close can be regulated by the counterweight, which is movable on its arm by means of appropriate connecting rods, from the base of the tower.

This method of regulation has been found to answer very well in practice, but it has several grave objections. The construction is necessarily such that there are a large number of joints on which the wear is very considerable; and with so many movable parts the liability to derangement is greatly increased. The failure of any of the parts during a high wind would endanger the safety of the wheel, and perhaps cause its destruction. The second form of mill, that using the vane-governor, is much simpler in construction, has fewer parts, and is consequently more durable. It is, therefore, to a considerable extent supplanting the older form. The wheel in it is solid—that is, without movable sections—and is turned about a vertical axis in such a way that its angle with the direction of the wind varies with the pressure of the latter. The devices by which this is accomplished vary somewhat in different mills, but the method is essentially the same in all. In one, a small vane, placed back of the wheel, is hinged upon the frame of the large rudder-vane, and when the wheel is at rest hangs vertically downward. It is connected by means of rods with the wheel in such a way that, when the pressure on this exceeds a certain amount, the vane will be raised toward an horizontal position. In so moving it turns the wheel by suitable mechanism toward the rudder-vane. When the pressure of the wind is sufficiently great the small vane is raised to an horizontal position and the wheel swings parallel with the rudder. The whole apparatus, wheel and rudder, then becomes simply a weather-vane, is exposed as little as possible to the wind, and is in the best position to escape injury when this is very high.

The wheel can be adjusted to close at any desired wind-pressure by means of a sliding weight upon the arm of the small vane. It may be turned by hand edgewise to the wind by a chain passing to the ground. The working parts of another vane-governor mill of excellent design are shown in Fig. 1. A portion of the wind-wheel is represented at L L, the rudder-vane at M, and the small governor-vane at N. This latter is in a plane parallel with the face of the wheel, at a slight distance back of it, and extends beyond its edge. The wheel is supported upon an iron frame, 1, which turns within the tubing 17 and the additional bearing 18. The wheel-shaft passes through the

Fig. 2.



bearing 2 and gives motion to the pump-rod by a crank, 10, as shown. To one side of the frame 1 a weighted lever is pivoted, which terminates in a toothed segment. This gears with a curved rack on the frame of the rudder-vane, so that, moving the lever upward, the rudder and wheel approach each other. The chain 35 passing over the pulley 20

allows this to be done by hand when desired, through a lever upon the lower end of the rod 25. This movement is the one which takes place when the wind-pressure upon the small vane is sufficient, the wheel swinging round toward the rudder-vane an amount proportional to the pressure. When this pressure is great the wheel swings parallel with the rudder and presents only its edge to the wind, as in the case of the other vane-mill. The weight 13 is movable upon the lever 26, and the wheel is therefore capable of nice adjustment.

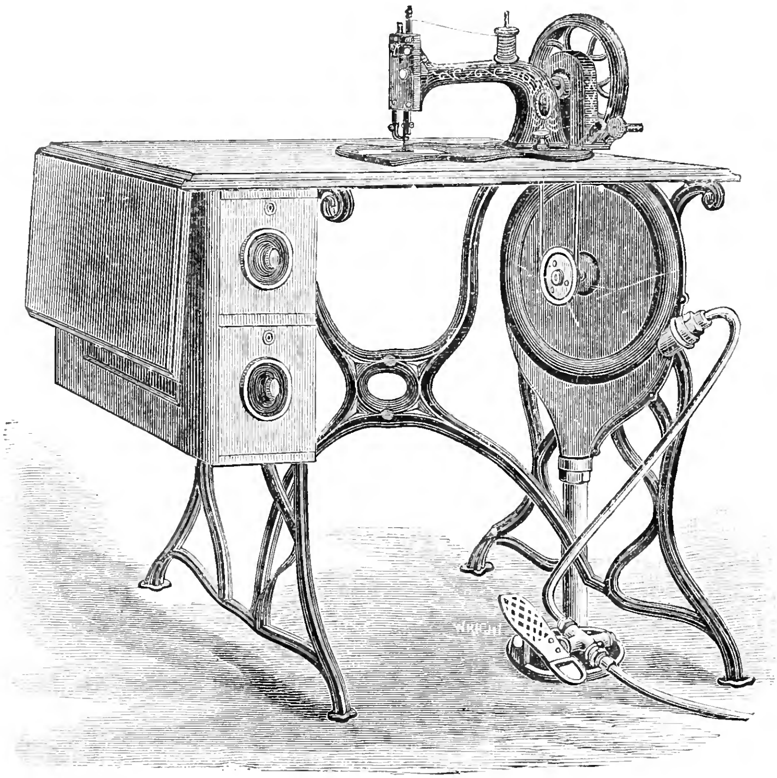
Windmills have gone very largely into use in the Western States, where the wind can be counted on with tolerable certainty. They are also used to a considerable extent in the East, both in the country and in the cities. Makers of wheels claim that in most localities they will work up to their full power seven hours out of the twenty-four, and a good portion of the remaining time will give some part of their full capacity. When a steady and continuous power is required, either at a definite time or whenever you happen to want it, the windmill is not suitable ; but for all uses in which such conditions do not hold, such as pumping water, it is admirably adapted. It is for this purpose employed on railroads, the farm, country seats, and to some extent in cities where the water-pressure is insufficient to carry the water to the upper stories of buildings, as many as five hundred being employed in New York City alone for this purpose. On the farm it would seem that a mill might be employed for a variety of purposes besides the pumping of water. Such operations as sawing wood, chopping feed, and perhaps churning, might readily be done by wind-power, by timing them to the periods when experience showed it could best be depended upon. With a well-constructed automatic mill of from two to five horse, such work could probably be performed with less trouble than in any other way. The only expense after the first cost is that for repairs and lubrication, neither of which is large. The power of any wheel depends, of course, on the velocity of the wind. They are usually rated with the wind at twenty miles an hour, and on this basis the powers of those made range from one eighth to forty horse, the smaller size being eight and a half feet in diameter and the latter sixty. The first cost of a good mill is from twenty-five to fifty per cent. higher than a steam-engine of corresponding power, with boiler.

While the windmill is peculiarly well adapted for pumping and allied purposes, it is not at all suited to most of the uses for which a small power is required. Water-power, on the other hand, is excellently adapted to such uses. Water-wheels are simple, easily managed, and the most efficient of known motors. They are especially suitable for use in the household, and, where sufficient water can be procured under a proper pressure, are at once the cheapest and most convenient motor for the shop. Water-wheels of large power, such as are required in manufacturing operations, can only be used in particular localities ; but those of comparatively small power can, owing to the very general

introduction of water under pressure into buildings in cities and towns, be used in very many places. As, however, the supply that most water-works are capable of furnishing is not at any time greatly in excess of the demand, wheels adapted for use upon house-pipes have to be, first of all, economical of water. They should also be constructed so that they are not liable to injury by water freezing in them, and be of low first cost. Several different wheels, designed to meet these requirements, are now made, and have been more or less widely introduced. One of the best of these, and one which has met with considerable favor in the market, is that shown in Fig. 2, the invention of Mr. O. J. Backus. It is exceedingly simple in construction, and has proved very satisfactory in use. It consists of a light but strong wheel, carrying buckets or vanes upon its rim, against which a jet of water impinges. The wheel is inclosed in an iron casing in which it revolves freely, the only points at which there is any friction being the bearings of the shaft. The manner of using the water constitutes the special feature of the motor, and is one that peculiarly adapts it to use on service-pipes, as it reduces the consumption to a minimum. In the wheels used in manufacturing, whether of the turbine or other pattern, motion is imparted by the continuous pressure of a considerable body of water. In this the motion is due to the successive impacts of a small jet having a high velocity, which allows of considerable work being performed with comparatively little water, as the striking force of the jet is utilized. In the smaller sizes of these motors, those capable of running a sewing-machine, the water-jet is but one sixteenth of an inch in diameter, while in the largest machines it does not exceed half an inch. A steady and uniform motion of the wheel is attained by placing the buckets very close together, so that the impulses follow each other in rapid succession. The water enters the wheel-casing at one side and escapes at the bottom, traversing but one quarter of it. As there is nothing to impede its flow, none can remain in the wheel and freeze in cold weather. The motors are manufactured in sizes varying from seven to forty-five inches' diameter of wheel, and from about one eighth to eight horse-power. The power obtained depends of course upon the pressure of the water, but they are designed to run at any pressure above fifteen pounds per square inch. This is easily obtained, as at most places where there are water-works there is a pressure of from twenty to forty pounds, and at some a much higher one. The manner of applying the motor to a sewing-machine is shown in Fig. 3. Perfect control over the supply of water is given by a valve operated by a treadle, which enables the operator to stop and start the machine as readily and quickly as by the ordinary foot-power. This method of regulating the speed of the machine has the great advantage that only the amount of power required is at any time used, thus saving the water to the utmost.

In a similar manner it can be used to drive any sort of light machinery, scroll-saws, dental engines, jewelers' lathes, coffee-mills, etc. One of the uses to which it is peculiarly well adapted is the blowing of organs. By a very simple mechanism the performer is given complete control over it, so that the bellows may be kept continually full. Among the heavier uses to which it has been applied are the running

Fig. 3



of printing-presses and the lifting of merchandise elevators in business houses. To all these uses it is in every way adapted, as it is always ready for use, is no expense except when running, needs no care, and is without danger. The extreme simplicity of the motor enables the makers to place it on the market at a very low first cost, varying from fifteen dollars in the case of the seven-inch to two hundred and seventy-five in that of the forty-five-inch double wheel.

The cost of operating these motors depends upon the locality in which they are used. In New York and Philadelphia the insufficiency of the water-supply prevents their use at all, but in most other places in this country they can be used at but nominal rates. The average

charge made by water-boards is from fifty to seventy-five dollars a year per horse-power, while for those used on sewing-machines the charge varies from three to six dollars. The cost for organs is between twelve and twenty dollars for the same time. When the motors are used for business purposes, their owners can usually get special rates depending upon the time they are actually employed. This price per horse-power is not greater than that of steam-engines of large size, and is very much less than the cost of any other form of motor of small power. This price is, however, based upon a condition of water-service which could not hold were the motors much more largely used than at present. The greatly increased demand for water that this would make would necessarily raise the price charged, but it could be very much increased and still leave these motors the most economical of small powers.

Another wheel of a somewhat peculiar construction, invented by Mr. Talley, is capable of being used either as a turbine or an overshot. The water is applied in such a manner that it strikes the wheel in a thin sheet, the sheet being undulating and wave-like in form, and impinging edgewise upon the wheel. The circumference of the wheel is provided with buckets set so as to make an angle of thirty degrees with the radial lines. The flanges forming the sides of the buckets are scalloped out to allow the water to freely escape when the wheel is employed in the former way. The wheel is set eccentric to its casing, approaching it closely on the inlet side. The casing in this portion has a number of curved channels terminating in the face opposite the buckets in a sinuous slit from which the water issues upon the wheel. The inlet-pipe enters this wave-line chute at the top of the casing, and the water is distributed throughout it by ducts terminating at different points. A valve at the top admits the water to one or more of these ducts as desired. The wave-line slit in the casing is wider near the top and gradually narrows toward the bottom, so that there is a greater weight of water on the wheel at the upper part, and the water issues with a higher velocity lower down. The sheet of water exerts a continuous pressure upon the wheel instead of moving it by successive impacts as in the case of the former motor. An outlet in the base allows the water to pass off when the wheel is used as an overshot, and one in the side of the casing provides an exit when it is used as a turbine. The wheel is said to be quite economical of water, and to run easily.

For light pieces of machinery, such as the sewing-machine, various sorts of spring motors have from time to time been devised, though none of them seem to have been brought into use. They are not properly motors, and are really quite valueless for the purpose of power, unless it be very slight, as that required in clocks. They are capable of giving out but a small amount of the power expended in winding them up, and, as this labor has to be done by hand, are very uneconom-

ical. A weight is a much better device, and yields a large per cent. of the power expended in raising it when it falls. Such an arrangement is, however, a thoroughly impracticable one, as a simple calculation will show. It takes about four hundred foot-pounds per minute to drive a sewing-machine, so that to run one an hour a weight of a fifth of a ton would have to fall sixty feet. The only practicable way of utilizing gravity for motive power is by the water-wheel, where the weight can fall continually, and the cost of raising it again is a minimum.

INDIGESTION AS A CAUSE OF NERVOUS DEPRESSION.

By T. LAUDER BRUNTON, M. D., F. R. S.

TO most men who are engaged in intellectual work, an autumn holiday has become a matter of necessity, and is not to be regarded as a mere luxury. During eleven months of the year many who are engaged in brain-work systematically overtax themselves, trusting to the month's holiday to bring them again into proper working order. Formerly this was not the case. Men seemed to be able to go on, not only month after month, but year after year, without any vacation at all. The circumstances under which they lived were different from those which exist now. The very means which facilitate our holidays—the network of railways which puts us into complete and easy communication with any part of the Continent of Europe, or the quick ocean-steamers which enable us to enjoy half of a six weeks' holiday on the other side of the Atlantic, as well as the telegraphic communications which will warn us in a moment, even at the most distant point of our travels, of any urgent necessity for an immediate return—all these are the very means which increase our labor during the greater part of the year. We live at high pressure; letters and telegrams keep us constantly on the *qui vive;* express trains hurry us miles away from home in the morning and back again in the evening, and the pressure of competition is so great that few men can afford either to take their work easily or to modify the constant strain of it by breaks of a day or two at a time. Wearied and exhausted, the hard-worked man goes off for his autumn holiday, and, if he can, will spend most of it in the open air, either yachting, walking by the seashore, strolling in the country, shooting on the moors, or climbing the Welsh hills or the Swiss mountains. After a month spent in any of these ways, the brain-worker comes back to town feeling himself a different man. Instead of his work being a slavery to him, as it was before he started, he feels it to be a pleasure; he gets through it with ease, and feels not only that the amount he can accomplish is greatly

increased, but that the quality is also improved. Perhaps for a short time after his return he is hardly in a condition to do brain-work at all. He sits down to his desk, but feels cramped in the unaccustomed posture, and he would rather work off the superabundant energy within him in a long walk or a stiff climb than restrain it with difficulty to the simple task of driving a quill. After a week or two he settles down and works steadily along with comfort and ease for a couple of months or more, when he again begins to sink below par. His apprehension is no longer so acute, his power of concentration is diminished, he can no longer fix his attention for any length of time upon one subject without a severe effort. His mental vision becomes less perspicuous, his ideas succeed each other more slowly, and find expression with greater difficulty, so that he communicates his thoughts with less fluency and less clearness than before. His temper, too, undergoes a change. Instead of regarding the daily occurrences of life with equanimity, and making the best of what can not be helped, irritation so slight as to be unfelt at other times provokes him to anger or peevishness, and even when he possesses sufficient self-control to restrain his feelings and prevent them from being manifested outwardly, to the annoyance of his friends or neighbors, the very effort of restraint seems to increase the internal irritation, until at last it either explodes in an ebullition of wrath on some comparatively trivial circumstance, or tells upon the digestion and nervous functions of the individual himself, diminishing the appetite or causing intense muscular weariness. In others, again, we find that along with or taking the place of irritability there is great mental depression. Everything is looked at from a gloomy point of view—himself, his friends, and his surroundings. He does not feel equal to his work; nothing that he does pleases him; he is apt to become distrustful of himself and jealous of others; apt to think that his friends are slighting him, or to fancy that he has offended them. Even when all external circumstances leave nothing to be desired, the unfortunate victim can not enjoy life. His mind is occupied with gloomy forebodings of miseries to come, or he becomes a prey to melancholy and depression without any apparent reason. This melancholy weighs most deeply upon him during the night, and if he happens to wake in the small hours of the morning, as he not unfrequently does, life seems not worth living, but a burden of which he would willingly be quit. Melancholy is at times associated with sleeplessness, and then the two evils react upon and increase each other. For this causeless sorrow has a similar effect to that of real sorrow. As Shakespeare says:

> "Sorrow's weight doth heavier grow,
> Through debt that bankrupt sleep doth sorrow owe."

At other times instead of sleeplessness there is an abnormal tendency to drowsiness, which sometimes comes on almost irresistibly at

the very moment when some important work, requiring all the best powers of the intellect, has to be performed, and rendering its performance either imperfect or completely impossible. As soon as the person goes to bed he falls asleep, and sleeps like a log till morning, when he rises with difficulty, feeling more exhausted than when he went to bed the night before, with perhaps a little tightness or pain over the forehead, eyes, or temples. After breakfast he feels somewhat revived, and will work comfortably for a short time, but about one and a half or two hours after the meal weariness overtakes him, again passing off after it has lasted a variable time. During the day this is repeated, fits of more or less energy alternating with periods of languor and exhaustion. These languid fits may be noticed two or three hours after lunch or dinner, and the sufferer is not unfrequently tempted to have recourse to the decanter of sherry or the brandy-bottle, not only to obtain relief from the feeling of personal discomfort, but to supply the energy which he feels to be necessary to enable him to do the work he has in hand. But this is a ruinous course to adopt, for not only does it pave the way to habits of confirmed drunkenness, and leads to tissue-changes which will ultimately abolish the functional activity of the most important organs of the body, and bring the individual to a premature grave; it enables him to do his work only imperfectly at the time. After an application to the decanter or bottle his powers may seem to himself to be as great as or greater than usual, but this is to a considerable extent a subjective feeling only, as he will probably be able to discover by results.

Now, how is it that such a change has come over the man in a few months, so that he seems to be a different individual from the one who returned, bright and lively, from his autumn holiday? How is it that the even-tempered man has become irritable, the clear-headed man muddled, the active lazy, the sober perhaps a tippler, and the cheerful and buoyant depressed and melancholy; that the brain performs all its functions with difficulty, and the mind is so altered that it does not seem to be that of the same individual? And yet, after all, the man is the same, and the brain is the same, at least in its essential structure, as it was a few months ago, and as it will be in a few months more, after another holiday has again put it in good working order. What has happened to it in the mean time to cause such a dreadful alteration? Not only does the brain seem exhausted, but the whole system appears to be languid and weak; instead of the man being able for a twenty or thirty miles' walk, one of a mile or two will produce fatigue, and sometimes an intense languor is felt without any exertion at all. And yet all this time he may have been trying to keep up his strength. He takes butcher's meat three times a day, perhaps also strong soups, to say nothing of wine, or brandy-and-soda, to pick him up. His tissues ought to be getting sufficient nourishment to enable them to do their work, and yet it is evident that they are not in a con-

dition to do so. The man, and very likely his friends also, wonders at his condition, and when he goes to his medical attendant to describe his case he says, "I take all sorts of strengthening things, and yet I feel so weak." If, instead of using these words, he were to say "*Because* I take all sorts of strengthening things I feel so weak," he would express a part at least of the truth. He and his friends who wonder with him forget that all the functions of life are more or less processes of combustion, and that they are subject to laws similar to those which regulate the burning of the coal in our fireplaces. Two things are necessary for the combustion, fuel and oxygen; sometimes it is the fuel that fails, but not unfrequently it is the oxygen. Sometimes, no doubt, our fires go out because the fuel is quite exhausted, but this is very rarely the case. It is only under very exceptional circumstances that we find a fire burned away so completely as to leave nothing but ash. Almost invariably some fuel still remains—often, indeed, enough to make up a good fire when properly put together. If we sift the ashes from the grate we generally find a quantity of cinders, sufficient to make a fire, and these have ceased to burn because they were unprovided with oxygen, which was prevented from reaching them by the ashes with which they were covered.

The reason why our fires burn low, or go out altogether, either is that we put on too much coal, or that we allow them to be smothered in ashes. It is the child who pokes the fire from the top to break the coal and make it burn faster; the wise man pokes it from below so as to rake out the ashes and allow free access of oxygen. And so it is with the functions of life, only that, these being less understood, many a man acts in regard to them as the child does to the fire. The man thinks that his brain is not acting because he has not supplied it with sufficient food. He takes meat three times a day, and beef-tea, to supply its wants, as he thinks, and he puts in a poker to stir it up in the shape of a glass of sherry or a nip from the brandy-bottle. And yet, all the time, what his brain is suffering from is not lack of fuel, but accumulation of ash; and the more he continues to cram himself with food, and to supply himself with stimulants, although they may help him for the moment, the worse does he ultimately become, just as the child's breaking the coal may cause a temporary blaze, but allows the fire all the more quickly to become smothered in ashes. It would seem that vital processes are much more readily arrested by the accumulation of waste products within the organs of the body than by the want of nutriment to the organs themselves. In all cases of fasting, whether voluntary or compulsory, life is prolonged to a much greater extent if water be freely supplied. Without water the individual quickly dies, however much other nourishment he may get, but with abundance of water he may live for a considerable time, even if he take no solid nutriment at all. Here it is not that the water acts as a food; it supplies no new energy to the body, for, unlike starch, or

sugar, or fat, or proteids, it has already undergone complete combustion. It can not, like them, unite any further with oxygen and thus supply energy.

And yet it is more essential to life than any of them, for without it the products of waste can not be removed from the tissues, and the vital fires, so to speak, are smothered in their own ash. If we take the excised muscle of a frog and stimulate it to repeated contraction, the contractions become feebler and feebler, until at last they cease altogether. But this is not because the fuel which the muscle contains in itself has been so completely burned up that none of it is left to furnish the requisite energy to the muscle; it is because the chemical processes necessary to the contraction of the muscle are arrested by the accumulation of the products of its own waste. If we wash these out of the muscle by sending through its vessels a weak solution of common salt, which supplies to it no new material, but which removes these waste products, the contractile power of the muscle will be restored.

This restoration takes place still more quickly and thoroughly if we employ a fluid which will supply oxygen, such as a solution of permanganate of potash, instead of a simple solution of salt, which merely washes out the muscular waste. The muscle is like a fire in the grate, which goes out long before the coal is entirely consumed, on account of the ash which smothers it, and just as we can revive the smoldering embers by supplying them with oxygen by the use of bellows, so the muscle revives more quickly when its supply of oxygen is increased. The quicker the fire burns the sooner will it be choked in ash, and the more rapidly the muscle contracts the sooner will it lose its powers.

The same is the case with the heart. The slowly beating heart of a crocodile will pulsate for a day or more after it has been cut out of the body, but the rapidly pulsating heart of a mammal will very soon cease to beat; and, the more rapidly it has been beating before the animal's death, the sooner will it cease to contract afterward. If the vagi are cut in the living animal so that the cardiac pulsations become excessively rapid, the heart's movement ceases almost as soon as the animal dies; but, if during life the vagi are irritated so as to make the heart contract very slowly indeed, it comes to resemble more nearly the heart of the crocodile, and continues to pulsate for a considerable time after the animal's death. The heart, too, resembles voluntary muscles, inasmuch as, if we wash out of it the products of its own waste, it will continue to beat for a much longer time than if we allow them to accumulate. By simply allowing a saline solution to circulate through the heart of a frog it may be kept beating for many hours longer than if it were left to itself. Both voluntary muscles and involuntary ones, such as the heart, cease to act, almost invariably, not by exhaustion of their energy-yielding substance, but by accumulation of the waste products within them; and muscles, both voluntary and involuntary,

are much less sensitive to this process of choking than the delicate structures of the nerve-centers. The gastrocnemius, or the heart of a frog, may retain its irritability for very many hours after its separation from the body, but the spinal cord of the same animal will rarely retain its irritability for a single hour after the circulation through it has been arrested. In warm-blooded animals the spinal cord is much more sensitive than in the frog, and, if the circulation in the lower part of the spinal cord be arrested in a rabbit by the pressure of a thumb upon the aorta for three or four minutes, the hind-legs of the animal will become completely paralyzed. Still more sensitive than the spinal cord is the brain, and if the circulation in the latter organ be arrested, consciousness is almost instantaneously abolished. In the animal body as in the steam-engine, the governing and directing parts are much more sensitive and easily acted upon than the working parts. A single touch of the hand to the steam-valve will set the engine in action or stop its movement, although the power of a thousand men applied to the fly-wheel would avail little or nothing. And in animals the nerve-centers are most sensitive and respond most readily to those circumstances which affect the organism. Not only are they exceedingly sensitive to the accumulation within them of the products of their own waste, but they are easily affected by alterations in the blood which circulates through them, and which conveys to them not only the products of muscular and glandular waste formed in other parts of the body, but also substances introduced from without, or absorbed from the intestinal canal. A single whiff of nitrite of amyl is sufficient to dilate the blood-vessels ; a fraction of a grain of pilocarpine will stimulate the sweat-glands to the most profuse secretion ; and half a drop of pure hydrocyanic acid is enough almost instantaneously to abolish consciousness and destroy the functional activity of the entire nervous system. In the case of the nitrite of amyl, the pilocarpine, or the hydrocyanic acid, we are able to distinguish the relation of cause and effect between the administration of the drug and the resulting changes in the organism. We do this, however, because of our knowledge, obtained by observation and experiment. Sometimes we can not do this. I have seen, for example, a person become aware of a peculiar sensation which, to the patient, was quite unaccountable, but of which I understood the reason, as I knew it to be due to the fumes from a bottle of nitrite of amyl, which the patient could not see. We may notice a similar occurrence in poisoned animals. The poison of the cobra causes paralysis of the spinal cord and nerves, and induces intense weakness, so that the limbs of the animal fail under it. I have seen an animal in this condition attempt to walk, and look round at its legs with a puzzled air, as though it could not understand what was the matter with it. It could not connect the weakness in its limbs with the introduction of the poison some time previously, although the connection between them was to me perfectly clear.

In the same way as the action of the cobra-poison was a mystery to the animal, an epidemic of typhoid fever was formerly to us a mysterious occurrence for which no reason could be assigned, but we now trace it to the absorption into the bodies of the sufferers of typhoid poison introduced from without. We are now completely alive to the important results produced by the absorption from the intestinal canal of poisonous matters, such as typhoid-germs, arsenic, or strychnine introduced into it from without. But perhaps we are not yet sufficiently alive to the important results produced by the absorption from the intestinal canal of substances generated in it by fermentation or imperfect digestion. We recognize the danger of breathing gas from a sewer, but probably we do not sufficiently realize that noxious gases may be produced in the intestine, and, being absorbed from it into the circulation, may produce symptoms of poisoning. And yet we know, from recorded observations, that such is the case, and that one at least of the chief components of sewer-gas, viz., sulphuretted hydrogen, may be produced in the intestine. This gas, which is so readily recognized by its smell resembling rotten eggs, was found by Dumarquay * to be very quickly absorbed indeed from the intestine when injected into the rectum, and to be quickly excreted from the lungs, sometimes appearing to produce, during its elimination, some inflammation of the trachea and bronchi. This was especially the case when small quantities were injected, and it seems not improbable that the production of this gas in the intestine may have something to do with the bronchitis which is not unfrequently observed in connection with digestive disturbance. In cases of indigestion this gas seems to be not unfrequently formed, because persons often complain of the taste of rotten eggs in the mouth or in the eructations. Even in such small quantities it is not improbable that it may exert a deleterious influence both upon the nervous system and upon the blood, for it is a powerful poison, in its action somewhat resembling hydrocyanic acid, though not so strong. It destroys ferments, and robs the blood-corpuscles and the seeds and roots of plants of their power to decompose peroxide of hydrogen; and, as this faculty seems to be closely associated with the processes of life, the sulphuretted hydrogen may be regarded as a powerful protoplasmic poison. Upon plants it has a curious action, differing very markedly from sulphurous acid. When plants are exposed to sulphurous acid, the leaves shrivel up, wither, and fall off, but, if the plant be now removed from the noxious influence of the gas and placed under favorable conditions, it will recover and send out fresh shoots. But, if it be exposed to the action of sulphuretted hydrogen, the leaves, instead of shriveling, simply begin to look flaccid, and droop. This seems, at first sight, to be a less deadly action than that of the sulphurous acid, but when the leaves have once begun to droop in this way the plant is dead, and does not recover when re-

* "Comptes Rendus," ix, p. 724.

moved from the action of the gas. This gas is rarely generated in the intestine in such a quantity as to give rise to symptoms of acute poisoning, but it has sometimes this effect. A case is recorded by Senator* in which a strong and previously healthy man became affected with a slight gastro-intestinal catarrh in consequence of some error in his diet, and on the second day afterward he had frequent eructations, smelling strongly of sulphuretted hydrogen. At the same time he suddenly became collapsed, pale, giddy, and with a rapid, small, compressible pulse. This lasted for one and a half to two minutes, and then passed off. The urine which he passed shortly afterward contained sulphuretted hydrogen. On the same day he had a second attack of a similar sort, and then, the bowels having been opened, he recovered completely. Nor is sulphuretted hydrogen the only gas which may be formed in the stomach. Marsh-gas is sometimes formed there too, and, in an exceedingly interesting case recorded by Dr. Ewald,† the quantity was so great that it first attracted the patient's attention by taking fire as it issued from his mouth while he was lighting a cigar. In this curious case the formation of gas alternated with the production of a great quantity of acid fluid in the stomach, which led to vomiting, or, as the patient himself expressed it, sometimes his gas-factory and sometimes his vinegar-factory was at work. It is possible that this gas may be formed in small quantities in many more cases than has hitherto been suspected, but its absorption does not seem to have anything like the same deleterious action as that of sulphuretted hydrogen. Nor was the acetic acid which was found by chemical analysis to exist in the acid secretion of the stomach in this case likely to be productive of any injurious effects after its absorption. But butyric acid, which is sometimes formed in the stomach in other cases of indigestion, has been shown by O. Weber to be a powerful poison acting chiefly on the nerve-centers.

It seems probable, however, that the substances, both gaseous and solid, formed in the stomach and absorbed from it, are upon the whole less poisonous in cases of indigestion than those which are produced lower down in the intestinal canal. We often find that patients are affected with severe gastric disorder without any affection of the nerve-centers beyond the weakness produced by the inability to digest food, while in many persons the mere omission to evacuate the contents of the bowels at the usual time will lead to a headache in the course of the day. No doubt such a headache as this may be due, to some extent, to the nervous irritation caused by the presence of the fæces in the intestine, but it seems quite possible that it is also due to the absorption of some of the fæcal matter itself. Nor do we at present know what effects are produced by the absorption of the various digestive juices themselves. That such absorption takes place there can be

* "Berliner klin. Wochenschr.," 1868, No. 24.

† "Reicherts und Du Bois-Reymond's Archiv.," 1874, p. 217.

little doubt. It has been demonstrated in the case of the bile, which is absorbed with great rapidity from the intestine and reëxcreted by the liver, so that it does not pass into the general circulation at all. But what becomes of the other digestive fluids, and the ferments they contain? The pepsin finds it way in minute quantities through the liver, and has been discovered in various tissues of the body and in the urine. This, however, matters but little, for it can not act upon the tissues themselves, inasmuch as they possess an alkaline reaction. But the case must be somewhat different with pancreatine, and if pancreatic fluid be absorbed from the intestine and pass through the liver unchanged, we should expect that it would have a very powerful action upon the tissues throughout the body, because there appears to be no reason why it should not act upon them just as it does upon the food in the intestine itself. It seems not at all unlikely, then, that the liver has got another function besides those usually assigned to it, viz., that of preventing the digestive ferments from reaching the general circulation so as to act upon the tissues. Now, we do find in the liver itself and in the bile a ferment having the same diastatic power as the pancreatic juice, but it does not appear in such quantities as one would expect if the whole of the pancreatic ferment were simply reëxcreted by the liver along with the bile, and, as we have no evidence that the ferment is destroyed during its action in the intestine, we are naturally led to think that it may undergo a change in the liver, the converse of that which it undergoes in the pancreatic gland during the process of secretion. In the pancreas itself we have no ready formed ferment, but we have a ferment-forming substance, which has recently become known under the name of zymogen, given to it by Heidenhain, but the writer heard it described by Kühne in his lectures on physiological chemistry delivered at Amsterdam in 1869. I quote verbatim from the notes which I took at the time of his lecture on the pancreas: "Glands which have no action on fibrine can be made active by digesting in very dilute acid and then neutralizing or alkalizing; there seeming to exist a ferment-forming substance in the pancreas." During digestion this ferment-forming substance or zymogen splits up and yields free ferment, and it seems not improbable that it is in the liver that this very ferment, after its digestive work is done, becomes again converted into the ferment-forming substance which may circulate throughout the tissues without doing them any injury.

Whether this be the case or not, however, with regard to the ferments of the gastric, pancreatic, and intestinal juices, all of which must pass through the liver before they reach the general circulation, there can be no doubt that the products of intestinal digestion do undergo very marked changes indeed in the liver, as is shown by the formation from them of very large quantities of a new substance, glycogen—a substance which is not contained in the products of the gastric and intestinal digestion which reach the liver, and yet which

is of the highest importance for the nutriment of the body. Under ordinary circumstances, nearly the whole of the sugar formed in the intestine and absorbed from it is arrested in the liver, so that very little passes into the general circulation and appears in the urine, although even in healthy persons traces of sugar are excreted by the kidneys. Under exceptional circumstances, however, sugar may pass through in considerable quantities, as, for example, when the individual takes, on an empty stomach, a large quantity of sirup. However healthy his organs may be, sugar will then appear in the urine. The same is the case in regard to albumen. Usually, the whole albuminous constituents of our food are so transformed in the stomach, intestines, and liver, that no albuminous substances of the kind which can pass through the kidneys get into the general circulation. But, if one takes such a quantity of eggs as to completely overtask the digestive powers, the egg-albumen will pass unchanged into the blood, and be excreted by the kidneys.

Other albuminous substances, the products of intestinal digestion, and peptones also, occasionally make their appearance in the urine, as well as egg-albumen. Even when the processes of assimilation are not so seriously interfered with as in these instances, we observe that products of nitrogenous waste frequently occur in the form of lithates in the urine. An excess of these indicates some pathological condition, even although it may be very trivial. We can not, indeed, say what the exact condition is, because we find lithates appearing in the urine after violent muscular exertion accompanied by profuse sweating, so that they may possibly represent some of the products of muscular waste ; but we also find that they occur in large quantities in the urine after slight indiscretions in diet, although no muscular exertion has been undergone, and in these cases we can hardly do otherwise than regard them as products of the imperfect assimilation of nitrogenous matters which ought to have been eliminated, not in the form of urates, but of urea. Now, physiological experiments and observations indicate that the liver is the chief if not the only part of the body in which urea is formed. This at least appears to be the case excepting in febrile conditions, in which, possibly, the urea may also be formed, to a considerable extent, in the muscles. The old notion, then, which connected the appearance of lithates in the urine with disordered function of the liver, is probably in a great measure correct. There is little or no reason to believe that these lithates are formed in the kidneys. They are, probably, simply separated by them from the blood, and their presence in the urine would therefore indicate their presence in the blood and tissues. Now, lithates in themselves do not appear to have any particularly injurious effects, either upon the nervous tissues or the muscles, but, as their presence indicates deficient assimilation, they may be accompanied by other substances which have a much more pernicious action, just as there are

many bad smells which, *per se*, though very disagreeable, have no marked poisonous action, while other very poisonous substances have comparatively little odor.* Yet the disagreeable odors which accompany sewer-gas, although perhaps not always dependent upon its poisonous constituents, warn us of the presence of gases which may be intensely poisonous. Nevertheless, just as the poisonous gases may be present without any disagreeable smell, so we may have substances circulating in the blood which have the most injurious effect upon the nerve-centers, without the presence of urates in the urine.

The importance of the functions of the liver in reference to assimilation is now generally recognized, although for a long time this, the largest gland in the body, was considered to have no other office than simply to secrete bile. Although the bile is useful in digestion it is not of primary importance in this process ; but its proper secretion is probably associated very closely with the assimilative functions of the liver, and if the biliary secretion does not take place properly we can hardly expect the assimilation to be perfect.

The greatest care appears to have been taken in the construction of the liver to prevent the bile from coming in contact with the blood, the ultimate radicals of the bile-ducts or biliary capillaries being placed as far from the blood capillaries as the structure of the liver will allow. Notwithstanding this care, the distance between the blood and the bile capillaries is small, though it is sufficient, under ordinary circumstances, to prevent the absorption of bile into the blood. But whenever an obstruction takes place to the exit of bile, and the presence of bile in the biliary capillaries increases, an absorption of this secretion occurs. Bile is secreted under very low pressure, and a very slight increase in this is sufficient to cause reabsorption. Such an increase as would not materially affect the secretion of other glands, such as the salivary gland, is sufficient to prevent the exit of bile through the biliary ducts, and cause its reabsorption into the blood. The excretion of bile is greatly aided by the pressure which is exerted upon it by the movements of the diaphragm during respiration, and indeed so low is the pressure under which the bile is secreted that, but for the assistance given by the respiratory movement, it would just barely find its way into the duodenum. Although we are accustomed to say "as bitter as gall," according to my own observations fresh human bile is not bitter. When it is thrown up in consequence of indigestion it is intensely bitter. On one occasion, when making experiments with digitalis, I had taken in the course of two days one grain of the pure alkaloid, and brought on symptoms of poisoning, with intense vomiting. During this I brought up a quantity of bile of a golden-yellow color, and without the least trace of bitterness. This circumstance struck me as being so peculiar that in my published results I hesitated to call it bile, although I did not

* Brunton and Power, "St. Bartholomew's Hospital Reports," 1877, p. 283.

see what else it could be.* But when it remains long in the gall-bladder it undergoes changes, and in some cases of vomiting that I have seen the vomited matters have been of a bright grass-green color. When examined, also, after death, the bile in the gall-bladder is not unfrequently found of a dark color, and the same is probably the case when it is retained in the gall-bladder for any length of time during life. How the Greeks arrived at the notion of giving the name "melancholy," i. e., black bile, to depression of spirits, we do not quite know, but certain it is that depression of spirits is very often associated with indigestion, and, moreover, that the form of indigestion with which we find depression of spirits associated is not so much gastric as intestinal, or, more probably, hepatic. According to Herbert Spencer, we require rapid evolution of nervous energy in order to have exhilaration of the spirits, and depression of nervous energy is associated with melancholy. Now, the effect of bile-acids circulating in the blood, as shown by physiological experiments, is to depress the reflex function of the spinal cord, the functions of the brain also, producing drowsiness ending in coma, and also weakening the circulation by paralyzing the cardiac ganglia.† Such a combination of actions is just the one required by Mr. Spencer's hypothesis to produce melancholia, and here we find ancient notions joining hands with modern science.
—*Practitioner.*

ORIENTAL MUSIC.

By S. AUSTEN PEARCE, Mus. D., Oxon.

INNUMERABLE questions arise in the mind whenever that mysterious art, called music, occupies our thoughts—questions respecting its source, its course or development in various epochs, its laws, object, action, limitations, and influence. These are not easily answered satisfactorily, and appear to have been as great problems to the ancients as they are to ourselves. For, attempting to penetrate the thick mists that veiled their past, they failed to discover the origin of any one musical instrument; and being completely baffled in their researches concerning the inception of musical systems, and also unable to account for the remarkable sway that their art-works exercised over hearers, they contented themselves with conserving these systems and art-works in their entirety, for the benefit of posterity.

We, who are always ready to invent theories for the explanation of phenomena, find ourselves extremely perplexed in accounting for various musical facts that at first sight seem simple and easily understood.

* Brunton "On Digitalis," p. 67.

† *Vide* Wickham Legge, "Bile, Jaundice, and Bilious Diseases," pp. 207, 216, 217.

If, therefore, we are unable to explain our music to ourselves, and the ancients could not explain their music to themselves, it should not cause surprise if we fail to comprehend their music. For, although it is said, "Human nature is the same in all ages," the tonal art, which appeals to every individual's own inner nature so very directly and intimately, reveals strongly marked differences among men.

The difficulties to be overcome in forming an adequate conception of the music of other peoples are, therefore, great. If, after persistent effort or even a life-long devotion to performance and composition, we find perplexing mysteries at every turn, we may naturally anticipate encountering inscrutable enigmas in the endeavor to comprehend the true nature of the forms of art specially adapted to the necessities of races so far removed in time and place, thought and feeling, as the ancient Orientals.

Even the music of the modern occupants of the East is so strange and foreign to our wants and inclinations, that many persons speak of it with disrespect; and travelers and generally well-informed artists, judging of its merits by the casual performances of poor peripatetic musicians, are frequently led to the belief that it is unworthy special regard. It would be more philosophical to assume that an art practiced throughout the Orient by all classes of persons, in all times, would, if seriously studied, present many aspects worthy of deep reflection. However little we may be able to sympathize with Chinese, Hindoos, Persians, and other peoples in their artistic aspirations, we should not be tempted to provoke a smile at their expense, but approach the study of their music with the greatest respect. In this spirit let us proceed.

Music and its instruments were commonly believed in the East to be gifts from Heaven, and therefore its cultivation and their preservation became religious duties. The Orientals took no credit to themselves for inventing the various extraordinary instruments with which they performed their wonder-working melodies, and, as will be presently shown, no modern nation has yet invented a really new one; for all those we employ are either enlarged or simplified forms of prototypes that were in use at the earliest times of which we have any record, and are really prehistoric.

The sacred books of the Chinese give a complete account of their organ—most exact measurements of the lengths, diameters, thickness, materials, etc., of each pipe, and so on—not to suggest improvements, or take credit for the devices mentioned; but simply that, should the instrument from any cause become obsolete, it could be revived; and thus this great gift, from some remote ancestor, would still be secured for future generations. Confucius and various emperors are portrayed performing on the *kin* (a stringed instrument), and music occupies the first rank among the sciences.

In India, Brahma himself is believed to have presented music to

mortals, and the invention of the seven-stringed *vina* is attributed to the god Nareda. Saraswati, the Minerva of the Hindoos, is represented playing on the lute, Krishna on the transverse flute, and harpists are adorned with wings.

In Egypt, the formation of the three-stringed lyre is attributed to one of the secondary gods. Osiris is regarded as the giver of the flute, Isis of songs, and Thoth of musical theory. In Egyptian hieroglyphics the *nofre*, a long-necked stringed instrument played with the hands, is labeled "good." In a satiric papyrus, now at Turin, Rameses III, as a lion, is playing chess with a favorite, figuring as a gazelle; and in another papyrus in the same collection these characters reappear playing respectively a lyre and harp, a crocodile is performing on a *nofre* and a slave on the double pipes. Music occupied a much more important place in the religion and daily life of Eastern peoples than it does among ourselves, where it is often regarded as an ordinary amusement or diversion, and unworthy any higher function. Hence the unwillingness so commonly manifested by very many religionists, having the best possible intentions—who accept the Bible, and think they regard all its teachings—to be cross-questioned with reference to their belief in its many statements respecting this art. They find the sacred writings of the Hebrews bearing testimony to its worth and power as well and fully as those of other ancient nations, and that not only the Jews (who were always extremely fond of and susceptible to its influence) are addressed, but also succeeding Christians; for, according to the New Testament, the blessed ones in heaven are unceasingly occupied in music.

The Hebrews were taught that Jehovah gave Moses special directions for the making of silver trumpets and a code of signals. They were allowed to mend musical instruments in the Temple on the Sabbath-day; believed the art to be efficacious in curing mental aberration, and the prophets not only employed it, but, as in the case of Elisha, appear to have found its use essential. Their music-schools, the arrangements for the Temple-worship, the various styles of composition adapted to different social occasions, prove the time and thought spent in the practice of music to have been, at least from our point of view, excessive; yet in no passages is long-continued indulgence in its exercise censured or moderation advised. The high estimation in which this art was held in times long past and our difficulty in understanding the matter find an illustration in the meeting of Saul with the company of prophets descending a hill, each playing upon a musical instrument. It would seem exceedingly strange to us if a king or president should meet and join a body of learned men in a similar manner.

The technical study of Oriental systems of music is rendered difficult from the fact that these are overlaid with a mass of symbolism, that makes accurate, positive definition frequently unattainable.

In some cases strange and extravagant hyperbole leads to a general notion being formed of the character of certain forms, but yet to great uncertainty as to their actual nature. In the case of some Oriental nations, the perfected systems, the theories and their symbolical analogies and illustrations came to be valued more highly than the music based upon them. The Chinese, for instance, compared at a very early period the twelve notes of the chromatic scale with the lunar zodiac, and the expression of each note with the expression of outward nature—the weather of each month.

Their various modes have characteristic significations. That of Koung (= fa) represents the emperor—the sublimity of his doctrine, the majesty of his countenance, and the high importance of his actions; the mode Cheng (= sol) represents the minister—his intrepidity in the exercise of his duties, firm administration of justice, and slight rigorousness; and so on, throughout the complete series.

The Hindoos were also led to personify all their modes, but their excited, unbridled imaginations led them to place in their heaven the presiding deity of each. Their systems are complicated, symbolical, mystical, and beautiful. They believed in miracle-working melodies, called Ragas, each having its own special power on rain, harvests, sun, wild beasts, etc., and the faith in their efficacy still exists. It is rarely tested because of the alleged difficulty in finding an executive artist competent to perform the music with the proper expression in the particular locality selected for the trial.

The Persians, who regarded music as physic for the soul, found in a tree and its roots and branches a fitting emblem and convenient illustration for their technical system of modes, and, in the strings of their lute, correspondences with their seasons.

The Chaldeans and Egyptians required the whole cosmos for an exemplification of their systems; and thus, through the Greeks, the expression "music of the spheres" has come down to us.

Here, at least, we find a link connecting the dead past with the living present. Pythagoras and the mathematical musicians of his age and country made the middle string of the Greek lyre typify the sun, and the others the planets; and even their opponents, Aristotle and the practical musicians, were led to acknowledge that, when this middle string was out of tune, the whole instrument was out of tune, but that if any other string were untuned the lyre would still be playable. Here evidence is found that there then existed a vague, glimmering notion of the peculiar and inherent importance of some one note, which we now fully recognize, and commonly speak of as the key-note—from which all the other notes are measured, and in which all find justification.

And, further, the Greek modes, Dorian, Phrygian, Lydian, etc., which were somewhat similar to the ecclesiastical modes that bear the same names interchanged, have given place in Europe to our modern

major and minor scales, which are exclusively used by all those peoples who do not employ the Hungarian system. Now, although these scales have hardly been in general use for two centuries, there is gradually growing up among ourselves a recognized scheme of characterization or symbolism analogous to the schemes formulated by the Orientals. For we not only speak of major modes as bright and genial, and minor modes as sorrowful and depressed, irrespective of the music to be cast in these modes—and also regard our sharp keys as brilliant, and flat keys as calm and soothing, irrespective also of the music to be rendered in them, and although we are perfectly certain of the fact that mathematically they present no variation—but we notice that the notes in any one key have each their special signification.

Attempts have been made to define these characteristics, which must be allowed to be successful, for thousands of persons are unanimous that their experiences agree.

The most satisfactory proof of this is that large choral bodies have been trained to sing from printed copies of music, at first sight, most elaborate compositions, simply by being taught to identify the various notes by recognizing uniformly their character, and thus to sing them correctly without the aid of an instrument. The societies acquainted with this—the tonic sol-fa system, in which particular ideas are associated with each note—have for twenty years competed successfully for prizes, at large festivals in England, with the best organizations trained in other methods.

We are, therefore, rapidly forming complex psychologic systems, side by side with our technical systems, which to the ancients would prove as strange and unaccountable as some of theirs do to us ; or even still more strange, for the want of sympathy would not be entirely due to difference of musical temperament of scales, or to mere remoteness of period and nation, but to the use of harmony and simultaneous melodies that render our music bewilderingly complex in its structure to those nations who do not employ polyphony.

An elaborate characterization of even one isolated interval—say of the sweet-sighing-sadness of the sixth sound of the Æolian harp, the dominant seventh of nature—could be no more intelligible to one who had never experienced the combination than the sweetness of honey be made known to one who had never tasted it.

Here one would willingly address thoughtful musicians, who strive to understand the present condition of their art, by tracing the history of its phases, being able to appeal to their technical knowledge of our own formal systems of scales, etc., in giving details of other and more complex systems, which can not be made readily comprehensible to the general public. But we must be content to pass on and speak of other links, connecting the present with the most remote ages.

No more ready proof of the great musical acquirements of the ancients can be found than in the marvelous skill shown in their instru-

ments. Many have become obsolete, but others are still in constant use, and are found with various modifications in all countries. They give evidence of high civilization at a very early period, not only in the costliness and rarity of the materials used, and the knowledge of the science of acoustics displayed in their production, but in the mental power required for their first conception.

The hollow-cone-shaped porcelain vases of China, that have five holes to be stopped so that the air within may be made to vibrate in certain determinate ways to produce with accuracy the notes required by the performer, are, as wind-instruments, marvels of inventive genius. The pipes of a Chinese organ are rendered dumb by a hole bored near the foot of each one, and which the player stops with his finger when the pipe is required to sound its note. Acousticians fail to comprehend this; and, although enormously large church-organs are built by ourselves, we do not really know the motion of the vibrating column of air in any one pipe, the wind with which it is supplied not entering it. Nor can we tell why one stopped with a plug at the top, when sounded, vibrates violently on two of its sides, the other two remaining quiescent. Various other phenomena, that are said to be fully understood in recent works on sound, are only partially accounted for.

There is a tendency to refer all instruments to respective epochs, according to their degrees of development, partly because our pianoforte has been so rapidly elaborated from the Irish harp, which alone had a tension-bar, and our harmonium from the Chinese reed, also by the key-board appliance, and partly because consistent theories are so easily invented. We should, therefore, be on our guard in this matter, as in others, respecting chronological sequences, and remember that many instruments have been periodically simplified, as in the case of the violin; or chosen for their simplicity, as in the case of the Greek lyre over that of the Egyptian harp, notwithstanding its extremely limited powers; and particularly the historic fact that most elaborate instruments were known in mythologic times in China.

Adopting the classification of Jubal—the sixth from Adam—"harp and organ" (commonly called "string and wind"), and adding the generally unrecorded percussive instruments to form the third genus, it is not difficult to invent a theory of development. For we may assume that the warrior's bow-string, giving a well-defined tone when pulled with the finger, led to two or more strings being systematized and plucked with the plectrum or struck with mallets, giving rise to the many forms of Egyptian harps, all of which are in the form of a bow, and have no "tension-bar" to resist the pull of the strings; then that the friction of two bows led to the violin species, by the addition and augmentation of resonating cavities for one bow and the modification of the other bow, which has only recently been made, and the addition of a finger-board.

Hand-clapping, not for applause, but rhythmic accentuation as practiced in the East, may be supposed to have led to the Jew's-harp and instruments consisting of bars free at one end, then to others free at both ends, then to plates free all round, as cymbals more or less concave, and subsequently to bells, sonorous boxes, drums, etc.

A simple reed or pipe may be supposed to have led to many pipes being systematized, their materials changed, their mouth-pieces varied, as whistle, beak, single reed, etc.; then that the powers of each pipe were increased by the boring of holes in it at certain particular points, much as a Gray's telephone increases the capacity of a single wire by enabling it to transmit in both directions several messages simultaneously ; then, finally, to the systemization of such pipes.

But here, at the end of our series, we find an instrument, the bagpipe, that figures in Chinese myths. However little we may relish the quality of the tone of this instrument, when it is badly played, and at only a short distance from us, we must give it the highest place in the scheme, and admire the skill displayed in its formation.

The real worth of Oriental music is not to be learned from routine practical musicians, who rarely know anything of the underlying principles of their art, but must be gained by a patient study of ancient writings, in which the respective theories are recorded. For the most part, the theories point to the possession or the possibility of greater art-works than any with which we have become acquainted ; and the cultivation of certain departments of the art, which we neglect.

The Chinese are sensitive to changes of pitch (transposition), to the exact agreement of the words of a song and its music, as well as to the expression imparted to their ordinary speech by vocal inflections ; while we are for the most part indifferent as to absolute pitch, set poetic rhythms to dance-tunes, have different verses to the same music, and less frequently speak with strongly marked variations of tone. Their belief that not only the voice of man, but all nature, should praise its Creator, led them to make an elaborate system of quality of tone (*timbre*), selecting eight kinds of materials from the animal, vegetable, and mineral kingdoms for the construction of musical instruments.

But, although they spent much labor in devising complete schemes, formulating scales, and calculating them with great nicety (like the modern Persians), even to the invention of the "equal temperament" (which European nations subsequently learned to use), in devising a regular notation, and in fact securing all the appliances necessary for the production of really great music, we fail to find them in possession of a single melody that would be generally acceptable to a modern audience. Their composers appear to be deficient in the power of imagination, without which it is impossible to invent a beautiful musical idea. We regard our melodies as so many happy thoughts, or felicitous expressions, developed with consistency and true to some particu-

lar mental mood; or at least presenting some recognizable sequential psychologic progression. Yet nevertheless, they have compositions intended to describe scenes, as if music to them conveyed definite intelligible ideas. Thus, one composition (although to us almost ludicrous from its awkwardness, shortness, and want of coherence) appears to have simulated for them the progress of a battle, being marked at various points, "The proclamation of the general," "His warriors preparing their fighting-men," "The general gives his orders," etc., ending with "Repose after victory."

The absence of harmony not only makes all these specimens unattractive, but the fact that they were conceived entirely free from the influence of harmonic design renders them foreign to our thoughts. We may whistle or hum a Strauss waltz or little Verdi tune with satisfaction, because these melodies were produced under the bias or dominion of harmonies, which are generally so simple and natural that we commonly say that they are implied in the melodic shape. For this reason an accompaniment may be extemporized or imagined. And the modern system of chords tending to create a desire for a constant return to the key-note, whenever a satisfactory termination is required, the absence of this acknowledged sound in Chinese melodies seems to make a cadence, in our sense of the word, impossible to them.

The Chinese language being monosyllabic, it lends itself readily to the Canto-Fermo style of song that is employed in ancestral worship, and which greatly resembles the style of the old Lutheran chorals, except that the melody of the former makes more skips upward and downward.

The lines of the poetry being four syllables in length in every strophe (as "See hoang sien tsow" of the "Ancestral Hymn"), and the notes being long and of equal length, a rhythmic uniformity is secured. But this is merely accidental, for in the secular melodies no evidence of a symmetrical rhythmic order or plan is observable, which also makes a definite rhythmic termination on a strong and anticipated accent as impossible as the definite tonal termination already noticed. The Chinese do not even appear to understand stress or accent, for in the orchestral score of the above hymn the instruments of percussion mark off groups of notes, not by greater stress, but by an increased number of instruments.

Turning to their neighbors, the Hindoos, on the contrary, we find extremely elaborate rhythmic designs (musical feet), and also phrases so symmetrical and compact that they are at once acceptable, and so coherent and consistent in their succession as to suggest words indicative of well-known moods. In this respect they present no difficulties, and are more easily supplied with accompaniments than those of the Chinese.

Our immediate acceptance of Indian music attests our Aryan fellowship.

The use of silk for strings and the employment of instruments of extreme softness in the East, sufficiently disprove the statement that ancient music was barbaric and noisy. Many instruments of percussion are soft as drops of water falling into a fountain. Chaldean music was soft and sentimental. Egyptian harps were not of powerful tone. The Hindoos have a flute with vibratory apparatus so extremely delicate that it is sounded by one end being suddenly pressed to the neck of the performer. The Greeks and Persians loved soft music, and singers did not strain their voices. The Hebrews alone among ancient people sang "with all their might" unrestrainedly, and delighted in making a grand consensus of tone in their choruses of voices and instruments and the clapping of hands. In other nations solo performances were more general, and among the Hindoos an executant would risk his reputation if he did not execute variations on a theme at each recurrence. These and other performances were most frequently extemporaneous. Conception and realization being thus conjoined, the result of sudden impulse, it was necessary for the player to warm with his theme until he became intensely interested in it; and his excited imagination to be stimulated by other influences until he succeeded in his artistic efforts, and in gratifying his audience. No cold reflection supervened, the composer was his own performer, his enthusiasm was perceived and his improvisations at every turn were surprises that gave delight.

A complete history of music would be a history of the world, so intimately is it found connected with the language, habits, poetry, religion, and life of the various nations. Our form of the art is alone adapted to our wants; and when we consider its enhanced powers, its modern counterpoint and harmony, we are at a loss to understand how Oriental music, with its greater limitations, could exercise so powerful a sway over its hearers.

Oriental music has, for ages, shed a benignant and salutary influance on the hearts, minds, and senses of millions of persons, and still is a source of gratification to more than half the population of the globe. It has given immediate expression to many various conditions of mind, has raised noble feelings and subdued painful ones; it has alleviated suffering and softened down coarseness and hardness of heart.

The joys and sorrows, aspirations and emotions of an age are sounded forth in its music; therefore that of the past is chiefly valuable as a contribution to historic national psychology. Let us so live that our own music, as a reflex image of ourselves, may attest our progress, not only in the physical sciences, but in nobleness of soul and all true worthiness.

THE SABBATH.*

By Professor JOHN TYNDALL, F. R. S.

I.

IN the opening words of a lecture delivered in this city four years ago, I spoke of the desire and tendency of the present age to connect itself organically with preceding ages. The expression of this desire is not limited to the connection of the material organisms of to-day with those of the geologic past. It is equally manifested in the domain of mind. To this source, for example, may be traced the philosophical writings of Mr. Herbert Spencer. To it we are indebted for the series of learned works on "The Sources of Christianity," by M. Renan. To it we owe the researches of Professor Max Müller in comparative philology and mythology, and the endeavor to found on these researches a "science of religion." In this relation, moreover, the recent work of Principal Caird † is highly characteristic of the tendencies of the age. He has no words of vituperation for the older phases of faith. Throughout the ages he discerns a purpose and a growth, wherein the earlier and more imperfect religions constitute the natural and necessary precursors of the later and more perfect ones. Even in the slough of ancient paganism, Principal Caird detects a power ever tending toward amelioration, ever working toward the advent of a better state, and finally emerging in the purer life of Christianity. ‡

These changes in religious conceptions and practices correspond to the changes wrought by augmented experience in the texture and contents of the human mind. Acquainted as we now are with this immeasurable universe, and with the energies operant therein, the guises under which the sages of old presented the Maker and Builder thereof seem to us to belong to the utter infancy of things. To point to illustrations drawn from the heathen world would be superfluous. We may mount higher, and still find our assertion true. When, for example, Moses and Aaron, Nadab and Abihu, and seventy elders of Israel are represented as climbing Mount Sinai, and actually seeing there the God of Israel, we listen to language to which we can attach no significance. "There is in all this," says Principal Caird, "much which, even when religious feeling is absorbing the latent nutriment contained in it, is perceived [by the philosophic Christian of to-day] to belong to the domain of materialistic and figurative conception." The

* Presidential address to the Glasgow Sunday Society, delivered in St. Andrew's Hall, October 25, 1880.

† "Introduction to the Philosophy of Religion."

‡ In Professor Max Müller's "Introduction to the Science of Religion" some excellent passages occur, embodying the above view of the continuity of religious development.

children of Israel received without idealization the statements of their great law-giver. To them the tables of the law were true tablets of stone, prepared, engraved, broken, and reëngraved ; while the graving-tool which inscribed the law was held undoubtingly to be the finger of God. To us such conceptions are impossible. We may by habit use the words, but we attach to them no definite meaning. "As the religious education of the world advances," says Principal Caird, "it becomes impossible to attach any literal meaning to those representations of God and his relations to mankind which ascribe to him human senses, appetites, passions, and the actions and experiences proper to man's lower and finite nature."

Principal Caird, nevertheless, ascribes to this imaging of the Unseen a special value and significance, regarding it as furnishing an objective counterpart to religious emotion, permanent but plastic—capable of indefinite change and purification in response to the changing moods and aspirations of mankind. It is solely on this mutable element that he fixes his attention in estimating the religious character of individuals or nations. "Here," he says, "the fundamental inquiry is as to the objective character of their religious ideas or beliefs. The first question is, not how they feel, but what they think and believe ; not whether their religion manifests itself in emotions more or less vehement or enthusiastic, but what are the conceptions of God and divine things by which these emotions are called forth ?" These conceptions "of God and divine things" were, it is admitted, once "materialistic and figurative," and therefore objectively untrue. Nor is their purer essence yet distilled ; for the religious education of the world still "advances," and is, therefore, incomplete. Hence the essentially fluxional character of that objective counterpart to religious emotion to which Principal Caird attaches most importance. He, moreover, assumes that the emotion is called forth by the conception. We have doubtless action and reaction here ; but it may be questioned whether the conception, which is a construction of the human understanding, could be at all put together without materials drawn from the experience of the human heart.*

The changes of conception here adverted to have not always been peacefully brought about. The "transmutation" of the old beliefs was often accompanied by conflict and suffering. It was conspicuously so during the passage from paganism to Christianity. In his work entitled "L'Église Chrétienne," Renan describes the sufferings of a group of Christians at Smyrna which may be taken as typical. The victims were cut up by the lash till the inner tissues of their bodies

* While reading the volume of Principal Caird I was reminded more than once of the following passage in Renan's "Antéchrist" : "Et d'ailleurs, quel est l'homme vraiment religieux qui répudie complètement l'enseignement traditionnel à l'ombre duquel il sentit d'abord l'idéal, qui ne cherche pas les conciliations, souvent impossibles, entre sa vieille foi et celle à laquelle il est arrivé par le progrès de sa pensée ? "

were laid bare. They were dragged naked over pointed shells. They were torn by lions; and finally, while still alive, were committed to the flames. But all these tortures failed to extort from them a murmur or a cry. The fortitude of the early Christians gained many converts to their cause; still, when the evidential value of fortitude is considered, it must not be forgotten that almost every faith can point to its rejoicing martyrs. Even these Smyrna murderers had a faith of their own, the imperiling of which by Christianity spurred them on to murder. From faith they extracted the diabolical energy which animated them. The strength of faith is, therefore, no proof of the objective truth of faith. Indeed, at the very time here referred to we find two classes of Christians equally strong—Jewish Christians and Gentile Christians—who, while dying for the same Master, turned their backs upon each other, mutually declining all fellowship and communion.

Thus early the forces which had differentiated Christianity from paganism made themselves manifest in details, producing disunion among those whose creeds and interests were in great part identical. Struggles for priority were not uncommon. Jesus himself had to quell such contentions. His exhortations to humility were frequent. "He that is least among you shall be greatest of all." There were also conflicts upon points of doctrine. The difference which concerns us most had reference to the binding power of the Jewish law. Here dissensions broke out among the apostles themselves. Nobody who reads with due attention the epistles of Paul can fail to see that this mighty propagandist had to carry on a life-long struggle to maintain his authority as a preacher of Christ. There were not wanting those who denied him all vocation. James was the head of the Church at Jerusalem, and Judeo-Christians held that the ordination of James was alone valid. Paul, therefore, having no mission from James, was deemed by some a criminal intruder. The real fault of Paul was his love of freedom, and his uncompromising rejection, on behalf of his Gentile converts, of the chains of Judaism. He proudly calls himself "the Apostle of the Gentiles." He says to the Corinthians: "I suppose I was not a whit behind the very chiefest apostles. Are they Hebrews? So am I. Are they Israelites? So am I. Are they of the seed of Abraham? So am I. Are they ministers of Christ? I am more; in labors more abundant, in stripes above measure, in deaths oft." He then establishes his right to the position which he claimed, by recounting in detail the sufferings he had endured. I leave it to you to compare this Christian hero with some of the "freethinkers" of our own day, who flaunt in public their cheap and trumpery theories of the great Apostle and the Master whom he served.

Paul was too outspoken to escape assault. All insincerity and double-facedness—all humbug, in short—were hateful to him; and even among his colleagues he found scope for this feeling. Judged by

our standard of manliness, Peter, in moral stature, fell far short of Paul. In that supreme moment when his Master required of him "the durance of a granite ledge" Peter proved "unstable as water." He ate with the Gentiles when no Judeo-Christian was present to observe him; but when such appeared he withdrew himself, fearing those which were of the circumcision. Paul charged him openly with dissimulation. But Paul's quarrel with Peter was more than personal. Paul contended for a principle, determined to shield his Gentile children in the Lord from the yoke which their Jewish co-religionists would have imposed upon them. "If thou," he says to Peter, "being a Jew, livest after the manner of the Gentiles, and not as do the Jews, why compellest thou the Gentiles to live as the Jews?" In the spirit of a true liberal he overthrew the Judaic preferences for days, deferring at the same time to the claims of conscience. "Let him who desires a Sabbath," he virtually says, "enjoy it; but let him not impose it on his brother who does not." The rift thus revealed in the apostolic lute widened with time, and Christian love was not the feeling which long animated the respective followers of Peter and Paul.

We who have been born into a settled state of things can hardly realize the primitive commotions out of which this tranquillity has emerged. We have, for example, the canon of Scripture already arranged for us. But to sift and select these writings from the mass of spurious documents afloat at the time of compilation was a work of vast labor, difficulty, and responsibility. The age was rife with forgeries. Even good men lent themselves to these pious frauds, believing that true Christian doctrine, which of course was *their* doctrine, would be thereby quickened and promoted. There were gospels and counter-gospels; epistles and counter-epistles—some frivolous, some dull, some speculative and romantic, and some so rich and penetrating, so saturated with the Master's spirit, that, though not included in the canon, they enjoyed an authority almost equal to that of the canonical books. The end being held to sanctify the means, there was no lack of manufactured testimony. The Christian world seethed not only with apocryphal writings, but with hostile interpretations of writings not apocryphal. Then arose the sect of the Gnostics—men who *know*—who laid claim to the possession of a perfect science, and who, if they were to be believed, had discovered the true formula for what philosophers called "the absolute." But these speculative Gnostics were rejected by the conservative and orthodox Christians of their day as fiercely as their successors the Agnostics—men who *don't know*—are rejected by the orthodox in our own. The martyr Polycarp one day met Marcion, an ultra-Paulite, and a celebrated member of the Gnostic sect. On being asked by Marcion whether he, Polycarp, did not know him, Polycarp replied, "Yes, I know you very well; you are the first-born of the devil."* This is a sample of the

* "L'Église Chrétienne," p. 450.

bitterness then common. It was a time of travail—of throes and whirlwinds. Men at length began to yearn for peace and unity, and out of the embroilment was slowly consolidated that great organization, the Church of Rome. The Church of Rome had its precursor in the Church *at* Rome. But Rome was then the capital of the world ; and, in the end, that great city gave the Christian Church established in her midst such a decided preponderance that it eventually laid claim to the proud title of "Mother and Matrix of all other Churches."

With jolts and oscillations, resulting at times in overthrow, the religious life of the world has spun down the "the ringing grooves of change." A smoother route may have been undiscoverable. At all events, it was undiscovered. Many years ago I found myself in discussion with a friend who entertained the notion that the general tendency of things in this world is toward an equilibrium of peace and blessedness to the human race. My notion was, that equilibrium meant not peace and blessedness, but death. No motive power is to be got from heat, save during its *fall* from a higher to a lower temperature, as no power is to be got from water save during its descent from a higher to a lower level. Thus also life consists, not in equilibrium but in the passage toward equilibrium. In man it is the leap from the potential, through the actual, to repose. The passage often involves a fight. Every natural growth is more or less of a struggle with other growths, in which, in the long run, the fittest survives. Some are, and must be, wiser than the rest ; and the enunciation of a thought in advance of the moment provokes dissent and thus promotes action. The thought may be unwise ; but it is only by discussion, checked by experience, that its value can be determined. Discussion, therefore, is one of the motive powers of life, and, as such, is not to be deprecated. Still one can hardly look without despair on the passions excited and the energies wasted over questions which, after ages of strife, are shown to be mere foolishness. Thus the theses which shook the world during the first centuries of the Christian era have, for the most part, shrunk into nothingness. It may, however, be that the human mind could not become fitted to pronounce judgment on a controversy otherwise than by wading through it. We get clear of the jungle by traversing it. Thus even the errors, conflicts, and sufferings of bygone times may have been necessary factors in the education of the world. Let nobody, however, say that it has not been a hard education. The yoke of religion has not always been easy, nor its burden light—a result arising, in part, from the ignorance of the world at large, but more especially from the mistakes of those who had the charge and guidance of a great spiritual force, and who guided it blindly. Looking over the literature of the Sabbath question, as catalogued and illustrated in the laborious, able, and temperate work of the late Mr. Robert Cox, we can hardly repress a sigh in thinking of the gifts and labors of intellect which this question has

absorbed, and the amount of bad blood it has generated. Further reflection, however, reconciles us to the fact that waste in intellect may be as much an incident of growth as waste in nature.

When the various passages of the Pentateuch which relate to the observance of the Sabbath are brought together, as they are in the excellent work of Mr. Cox, and when we pass from them to the similarly collected utterances of the New Testament, we are immediately exhilarated by a freer atmosphere and a vaster sky. Christ found the religions of the world oppressed almost to suffocation by the load of formulas piled upon them by the priesthood. He removed the load, and rendered respiration free. He cared little for forms and ceremonies, which had ceased to be the raiment of man's spiritual life. To that life he looked, and it he sought to restore. It was remarked by Martin Luther that Jesus broke the Sabbath deliberately, and even ostentatiously, for a purpose. He walked in the fields; he plucked, shelled, and ate the corn; he treated the sick, and his spirit may be detected in the alleged imposition upon the restored cripple of the labor of carrying his bed on the Sabbath-day. He crowned his protest against a sterile formalism by the enunciation of a principle which applies to us to-day as much as to the world in the time of Christ: "The Sabbath was made for man, and not man for the Sabbath."

Though the Jews, to their detriment, kept themselves as a nation intellectually isolated, the minds of individuals were frequently colored by Greek thought and culture. The learned and celebrated Philo, who was contemporary with Josephus, was thus influenced. Philo expanded the uses of the seventh day by including in its proper observance studies which might be called secular. "Moreover," he says, "the seventh day is also an example from which you may learn the propriety of studying philosophy. As on that day it is said God beheld the works that he had made, so you also may yourself contemplate the works of Nature." Permission to do this is exactly what the members of the Sunday Society humbly claim. The Jew, Philo, would grant them this permission, but our straiter Christians will not. Where shall we find such samples of those works of Nature which Philo commended to the Sunday contemplation of his countrymen as in the British Museum? Within those walls we have, as it were, epochs disentombed—ages of divine energy illustrated. But the efficient authorities—among whom I would include a short-sighted portion of the public—resolutely close the doors, and exclude from the contemplation of these things the multitudes who have only Sunday to devote to them. Taking them on their own ground, we ask, are the authorities logical in doing so? Do they who thus stand between them and us really believe those treasures to be the work of God? Do they or do they not hold, with Paul, that "the eternal power and Godhead" may be clearly seen from "the things that are made"? If they do—and they dare not affirm

that they do not—I fear that Paul, in his customary language, would pronounce their conduct to be "without excuse." *

Science, which is the logic of nature, demands proportion between the house and its foundation. Theology sometimes builds weighty structures on a doubtful base. The tenet of Sabbath observance is an illustration. With regard to the time when the obligation to keep the Sabbath was imposed, and the reasons for its imposition, there are grave differences of opinion between learned and pious men. Some affirm that it was instituted at the Creation in remembrance of the rest of God. Others allege that it was imposed after the departure of the Israelites from Egypt, and in memory of that departure. The Bible countenances both interpretations. In Exodus we find the origin of the Sabbath described with unmistakable clearness, thus: "For in six days the Lord made heaven and earth, the sea, and all that in them is, and rested the seventh day. *Wherefore* the Lord blessed the seventh day, and hallowed it." In Deuteronomy this reason is suppressed and another is assigned. Israel being a servant in Egypt, God, it is stated, brought them out of it through a mighty hand and by a stretched-out arm. "*Therefore* the Lord thy God commanded thee to keep the Sabbath-day." After repeating the ten commandments, and assigning the foregoing origin to the Sabbath, the writer in Deuteronomy proceeds thus: "These words the Lord spake unto all your assembly in the mount, out of the midst of the fire, of the cloud, and the thick darkness, with a loud voice; and he added no more." But in Exodus God not only added more, but something entirely different. This has been a difficulty with commentators—not formidable, if the Bible be treated as any other ancient book, but extremely formidable on the theory of plenary inspiration. I remember in the days of my youth being shocked and perplexed by an admission made by Bishop Watson in his celebrated "Apology for the Bible," written in answer to Tom Paine. "You have," says the Bishop, "disclosed a few weeds which good men would have covered up from view." That there were "weeds" in the Bible requiring to be kept out of sight was to me, at that time, a new revelation. I take little pleasure in dwelling upon the errors and blemishes of a book rendered venerable to me by intrinsic wisdom and imperishable associations. But when that book is wrested to our detriment, when its passages are invoked to justify the imposition of a yoke, irksome because unnatural, we are driven in self-defense to be critical. In self-defense, therefore, we plead these two discordant accounts of the origin of the Sabbath, one of which makes it a purely Jewish institution, while the other, unless regarded as a mere myth and figure, is in violent antagonism to the facts of geology.

With regard to the alleged "proofs" that Sunday was introduced

* I refer, of course, to those who object to the opening of the museums on religious grounds. The administrative difficulty stands on a different footing. But surely *it* ought to vanish in presence of the public benefits which in all probability would accrue.

as a substitute for Saturday, and that its observance is as binding upon Christians as their Sabbath was upon the Jews, I can only say that those which I have seen are of the flimsiest and vaguest character. "If," says Milton, "on the plea of a divine command, they impose upon us the observances of a particular day, how do they presume, without the authority of a divine command, to substitute another day in its place?" Outside the bounds of theology no one would think of applying the term "proofs" to the evidence adduced for the change; and yet on this pivot, it has been alleged, turns the eternal fate of human souls.* Were such a doctrine not actual it would be incredible. It has been truly said that the man who accepts it sinks, in doing so, to the lowest depth of atheism. It is perfectly reasonable for a religious community to set apart one day in seven for rest and devotion. Most of those who object to the Judaic observance of the Sabbath recognize not only the wisdom but the necessity of some such institution, not on the ground of a divine edict, but of common sense.† They contend, however, that it ought to be as far as possible a day of cheerful renovation both of body and spirit, and not a day of penal gloom. There is nothing that I should withstand more strenuously than the conversion of the first day of the week into a common working day. Quite as strenuously, however, should I oppose its being employed as a day for the exercise of sacerdotal rigor.

The early reformers emphatically asserted the freedom of Christians from Sabbatical bonds; indeed, Puritan writers have reproached them with dimness of vision regarding the observance of the Lord's day. "The fourth commandment," says Luther, "literally understood, does not apply to us Christians; for it is entirely outward, like other ordinances of the Old Testament, all of which are now left free by Christ. If a preacher," he continues, "wishes to force you back to Moses, ask him whether you were brought by Moses out of Egypt? If he says no, then say, How, then, does Moses concern me, since he speaks to the people that have been brought out of Egypt? In the New Testament Moses comes to an end, and his laws lose their force. He must bow in the presence of Christ." "The Scripture," says Melanchthon, "allows that we are not bound to keep the Sabbath; for it teaches that the ceremonies of the law of Moses are not neces-

* In 1785 the first mail-coach reached Edinburgh from London, and in 1788 it was continued to Glasgow. The innovation was denounced by a minister of the Secession Church of Scotland as "contrary to the laws both of Church and state; contrary to the laws of God; contrary to the most conclusive and constraining reasons assigned by God; and calculated not only to promote the hurt and ruin of the nation, but also the eternal damnation of multitudes."—(Cox, vol. ii, p. 248.) Even in our own day there are clergymen foolish enough to indulge in this dealing out of damnation.

† "That public worship," says Milton, "is commended and inculcated as a voluntary duty, even under the Gospel, I allow; but that it is a matter of compulsory enactment, binding on believers from the authority of this commandment, or of any Sinaitical precept whatever, I deny."

sary after the revelation of the Gospel. And yet," he adds, "because it was requisite to appoint a certain day that the people might know when to assemble together, it appeared that the Church appointed for this purpose the Lord's day." I am glad to find my grand old namesake on the side of freedom in this matter. "As for the Sabbath," says the martyr Tyndale, "we are lords over it, and may yet change it into Monday, or into any other day, as we see need; or may make every tenth day holy day, only if we see cause why. Neither need we any holy day at all if the people might be taught without it." Calvin repudiated "the frivolities of false prophets who, in later times, have instilled Jewish ideas into the people. Those," he continues, "who thus adhere to the Jewish institution go thrice as far as the Jews themselves in the gross and carnal superstition of Sabbatism." Even John Knox, who has had so much Puritan strictness unjustly laid to his charge, knew how to fulfill on the Lord's day the duties of a generous, hospitable host. His Master feasted on the Sabbath-day, and he did not fear to do the same on Sunday.

Toward the end of the sixteenth century, demands for a stricter observance of the Sabbath began to be made—probably in the first instance with some reason, and certainly with good intent. The manners of the time were coarse, and Sunday was often chosen for their offensive exhibition. But, if there was coarseness on the one side, there was ignorance both of nature and human nature on the other. Contemporaneously with the demands for stricter Sabbath rules, God's judgments on Sabbath-breakers began to be pointed out. Then and afterward "God's judgments" were much in vogue, and man, their interpreter, frequently behaved as a fiend in the supposed execution of them. But of this subsequently. A Suffolk clergyman named Bownd, who, according to Cox, was the first to set forth at large the views afterward embodied in the Westminster Confession, adduces many such judgments. One was the case of a nobleman "who for hunting on the holy day was punished by having a child with a head like a dog's." Though he cites this instance, Bownd, in the matter of Sabbath observance, was very lenient toward noblemen. With courtier-like pliancy, which is not without its counterpart at the present time, he makes an exception in their favor: "Concerning the feasts of noblemen and great personages or their ordinary diet upon this day, because they represent in some measure the majesty of God on the earth, in carrying the image, as it were, of the magnificence and puissance of the Lord, much is to be granted to them."

Imagination once started in this direction was sure to be prolific. Instances accordingly grew apace in number and magnitude. Memorable examples of God's judgments upon Sabbath-breakers, and other like libertines, in their unlawful sports happening within this realm of England, were collected. Innumerable cases of drowning while bathing on Sunday were adduced, without the slightest attention to the

logical requirements of the question. Week-day drownings were not dwelt upon, and nobody knew or cared how the question of proportion stood between the two classes of bathers. The civil war was regarded as a punishment for Sunday desecration. The fire of London and a subsequent great fire in Edinburgh were ascribed to this cause; while the fishermen of Berwick lost their trade through catching salmon on Sunday. A Nonconformist minister named John Wells, whose huge volume is described by Cox as "the most tedious of all the Puritan productions about the Sabbath," is specially copious in illustration. A drunken peddler, "fraught with commodities" on Sunday, drops into a river: God's retributive justice is seen in the fact. Wells traveled far in search of instances. One Utrich Schrœtorus, a Swiss, while playing at dice on the Lord's day, lost heavily, and apparently to gain the devil to his side broke out into this horrid blasphemy: "If fortune deceive me now I will thrust my dagger into the body of God." Whereupon he threw the dagger upward. It disappeared, and five drops of blood, which afterward proved indelible, fell upon the gaming-table. The devil then appeared, and with a hideous noise carried off the vile blasphemer. His two companions fared no better. One was struck dead and turned into worms, the other was executed. A vintner who on the Lord's day tempted the passers-by with a pot of wine was carried into the air by a whirlwind and never seen more. "Let us read and tremble," adds Mr. Wells. At Tidworth a man broke his leg on Sunday while playing at football. By a secret judgment of the Lord the wound turned into a gangrene, and in pain and terror the criminal gave up the ghost.

You may smile at these recitals, but is there not a survival of John Wells still extant among us? Are there not people in our midst so well informed regarding "the secret judgments of the Lord" as to be able to tell you their exact value and import, from the damaging of the share-market through the running of Sunday trains to the calamitous overthrow of a railway bridge? Alphonso of Castile boasted that, if he had been consulted at the beginning of things, he could have saved the Creator some worlds of trouble. It would not be difficult to give the God of our more rigid Sabbatarians a lesson in justice and mercy; for his alleged judgments savor but little of either. How are calamities to be classified? Almost within ear-shot of those who note these Sunday judgments, the poor miners of Blantyre are blown to pieces, while engaged in their sinless week-day toil. A little farther off the bodies of two hundred and sixty workers, equally innocent of Sabbath-breaking, are entombed at Abercarne. Dinas holds its sixty bodies, while the present year has furnished its fearful tale of similar disasters. Whence comes the vision which differentiates the Sunday calamity from the week-day calamity, seeing in the one a judgment of Heaven, and in the other a natural event? We may wink at the ignorance of John Wells, for he lived in a pre-scientific

age; but it is not pleasant to see his features reproduced, on however small a scale, before an educated nation in the latter half of the nineteenth century.

Notwithstanding their strictness about the Sabbath, which possibly carried with it the usual excess of a reaction, some of the straitest of the Puritan sect saw clearly that unremitting attention to business, whether religious or secular, was unhealthy. Considering recreation to be as necessary to health as daily food, they exhorted parents and masters, if they would avoid the desecration of the Sabbath, to allow to children and servants time for honest recreation on other days. They might have done well to inquire whether even Sunday devotions might not, without "moral culpability" on their part, keep the minds of children and servants too long upon the stretch. I fear many of the good men who insist on a Judaic observance of the Sabbath, and who dwell upon the peace and blessedness to be derived from a proper use of the Lord's day, generalize beyond their data, applying the experience of the individual to the case of mankind. What is a conscious joy and blessing to themselves they can not dream of as being a possible misery, or even a curse, to others. It is right that your most spiritually-minded men—men who, to use a devotional phrase, enjoy the closest walk with God—should be your pastors. But they ought also to be practical men, able to look not only on their personal feelings, but on the capacities of humanity at large, and willing to make their rules and teachings square with these capacities. There is in some minds a natural bias toward religion, as there is in others toward poetry, art, or mathematics; but the poet, artist, or mathematician, who would seek to impose upon others not possessing his tastes the studies which give him delight, would be deemed an intolerable despot. The philosopher Fichte was wont to contrast his mode of rising into the atmosphere of faith with the experience of others. In his case the process, he said, was purely intellectual. Through reason he reached religion; while in the case of many whom he knew this process was both unnecessary and unused, the bias of their minds sufficing to render faith, without logic, clear and strong. In making rules for the community these natural differences must be taken into account. The yoke which is easy to the few may be intolerable to the many, not only defeating its own immediate purpose, but frequently introducing recklessness or hypocrisy into minds which a franker and more liberal treatment would have kept free from both.*—*Nineteenth Century.*

* "When our Puritan friends," says Mr. Frederick Robertson, "talk of the blessings of the Sabbath, we may ask them to remember some of its curses." Other and more serious evils than those recounted by Mr. Robertson may, I fear, be traced to the system of Sabbath observance pursued in many of our schools. At the risk of shocking some worthy persons, I would say that the invention of an invigorating game for fine Sunday afternoons, and healthy in-door amusement for wet ones, would prove infinitely more effectual as an aid to moral purity than most of our plans of religious meditation.

BIOGRAPHICAL SKETCH OF PROFESSOR DUMAS.

By A. W. HOFMANN.*

THIS able chemist and distinguished man of science, now eighty years of age, and still fulfilling, with almost youthful freshness, the duties of Permanent Secretary to the Academy of Sciences, has been identified with the progress of science in France during half a century, and has gone through an amount of active, diversified labor which has hardly a parallel among his contemporaries.

JEAN-BAPTISTE ANDRÉ DUMAS was born at Alais, in the department of Gard, July 14, 1800. His father was clerk of the municipality, and a cultivated man. He early studied Latin in the college of his native town, and became interested in the classical traditions of his neighborhood, which had many imposing remains of Roman antiquity. But the situation was one calculated to foster an interest also in the objects of nature and the processes of science and art. There were coal-mines, glass-works, brick-yards, tile-works, manufactories of coarse earthenware, lime-kilns, vitriol-factories, and mines of iron, lead, and antimony, all in the immediate region of Alais. The lessons of these industries were not lost upon young Dumas, who, at fourteen years of age, had acquired a rudimentary knowledge of the several natural sciences. At this time he was apprenticed to an apothecary. But there was not much opportunity of scientific study, and this, added to the political and military distraction of the time, inspired him with a strong desire to quit his native town.

In 1816 Dumas accordingly went to Geneva. Here he found scope for study and opportunities to begin a career. He attended the lectures on botany by M. de Candolle, on physics by M. Pictet, and on chemistry by M. Gaspard de la Rive. He had the superintendence of a large pharmaceutical laboratory, which was found deficient in apparatus. But a supply was rapidly improvised. To obtain gas-jars, lamp-chimneys were closed with watch-glasses, cemented on with wax. An old bronze syringe was turned into an air-pump, and barometer-tubes bent over a flame completed the stock of apparatus. Gradually the laboratory improved. As the ambition of the young Professor grew, he began to long for a chemical balance. This wish also was satisfied; with the aid of some workmen in a watch-maker's shop an instrument was constructed which enabled him to begin his analytical researches. He here commenced earnestly the study of chemistry, and began at once the work of research. One of his little discoveries had the following result: When analyzing various sulphates and other salts of commerce, he had observed that the water they contained was

* Condensed from the excellent "Life of Dumas" in "Nature," February 6, 1880.

present in definite equivalents. He had not found this recorded anywhere, and had, therefore, taken great pains to establish the accuracy of his observations. When the investigation was finished, he went one morning early to M. de la Rive, and timidly submitted to him the manuscript embodying the results of his inquiry. While glancing over it, M. de la Rive could not conceal his surprise. When he had come to the end he said to the young student, "Is it you, my boy, who have made these experiments?" "Certainly." "And they have taken you a good deal of time to perform?" "Of course they have." "Then I must tell you that you have had the good fortune to meet Berzelius on the same field of research. He has preceded you, but he is older than you, and so you ought not to bear him ill will on this account." Dumas, not a little embarrassed, was unable to utter a single word. It was, in fact, his first interview with M. de la Rive, whose lectures he had attended, but whom he had never personally accosted. But his perplexity was not to last long. With the utmost good nature M. de la Rive put an end to his gloomy reflections by taking his arm and saying, "Come along and breakfast with me." Before long the conversation had become animated and cheerful. The acquaintance was made, and the kindly feeling of his teacher won by Dumas at this breakfast never subsequently failed him.

This was when Dumas was eighteen years of age. For the next four years he worked with great assiduity in experimental chemistry, and especially, in association with Prévost, upon the problems of organic chemistry, in which they were pioneers.

In 1822 Dumas might have settled at Geneva, and many circumstances led him to think seriously of doing so. An incident, however, which happened at that time, and which at first sight seemed in no way likely to influence a well-matured plan of life, induced him within a few days to change his mind. He made the acquaintance of a man, among whose varied gifts the fascinating sway he exercised over youthful minds was not the least. Let me try to give the story in the very words in which I heard it from Dumas's mouth.

"One day," he said, "when I was in my study completing some drawings at the microscope, and, it must be added, rather negligently attired, in order to enable me to move more freely, some one mounted the stairs, stopped on my landing, and gently knocked at the door. 'Come in,' said I, without looking up from my work. On turning round I was surprised to find myself face to face with a gentleman, in a bright blue coat with metal buttons, a white waistcoat, nankeen breeches, and top-boots. This costume, which might have been the fashion under the Directory, was then quite out of date. The wearer of it, his head somewhat bent, his eyes deep-set but keen, advanced with a pleasant smile, saying, 'Monsieur Dumas?' 'The same, sir; but excuse me.' 'Don't disturb yourself. I am M. de Humboldt, and did not wish to pass through Geneva without having had the pleasure

of seeing you.' Throwing on my coat, I hastily reiterated my apologies. I had only one chair. My visitor was pleased to accept it, while I resumed my elevated perch on the drawing-stool. Baron Humboldt had read the papers published by M. Prévost and myself on blood, which had just appeared in the "Bibliothèque Universelle," and was anxious to see the preparations I had by me. His wish was soon gratified. 'I am going to the Congress at Verona,' said he, 'and I intend to spend some days at Geneva, to see old friends and to make new ones, and more especially to become acquainted with young people who are beginning their career. Will you act as my cicerone? I warn you, however, that my rambles begin early and end late. Now, could you be at my disposal, say, from six in the morning till midnight?' This proposal, which was of course accepted with alacrity, proved to me a source of unexpected pleasure. Baron Humboldt was fond of talking; he passed from one subject to another without stopping. He obviously liked being listened to, and there was no fear of his being interrupted by a young man who for the first time heard Laplace, Berthollet, Gay-Lussac, Arago, Thenard, Cuvier, and many others of the Parisian celebrities, spoken of with familiarity. I listened with a strange delight; a new horizon began to dawn upon me. Save the time devoted to some visits, I was allowed to remain the whole day with Humboldt, who darted from point to point over the vast range of his recollections, while I endeavored to keep pace with the uninterrupted flow of his narrative. Sometimes the mountain scenery would remind him of the Cordilleras, though it must be confessed he did not think much even of Mont Blanc. Sometimes he turned to science, and then astronomy and physics, chemistry, and the natural history branches would, in rapid succession, come in for their share in the dialogue, or rather monologue, which, spoken in a low, somewhat monotonous tone, would have scarcely appeared impressive had it not been for some waggish pleasantry which now and then escaped, as it were, involuntarily. But, at any rate, if his voice failed to be effective, the glance of his eye was sufficient to rivet his hearers' attention.

"At the end of a few days Baron Humboldt left Geneva. After his departure the town seemed empty to me. I felt as if spellbound. The memorable hours I had spent with that irresistible enchanter had opened a new world to my mind. I had been more especially impressed with what he had told me of Parisian life, of the happy collaboration of men of science, and of the unlimited facilities which the French capital offered to young men wishing to devote themselves to scientific pursuits. I began to think that Paris was the only place where, under the auspices of the leaders of physical and chemical science, with whom I had no doubt I should soon become acquainted, I might hope to find the advice and assistance which would enable me to carry out the labors over which I had been pondering for some time. My mind was soon made up—'I must go to Paris.'"

The interest with which Dumas recounts this incident, which brought his stay in Geneva to a somewhat sudden termination, leaves no doubt as to the deep impression which the short intercourse with Alexander von Humboldt had made upon his mind. We have here, indeed, one more illustration of the peculiar predilection of the German *savant* for youthful inquirers, of the sagacity with which he discovered rising talent, and of the irresistible fascination which no one was able to withstand. It is well known what a powerful patron he proved to Liebig, who has left us a charming account of his first acquaintance with the famous traveler; and it is certainly worthy of note that two inquirers, whose labors subsequently carried them to the head of chemical science, should each have been befriended on the very threshold of his career by the same master mind, so that in later years they never ceased to acknowledge in affectionate terms the debt of gratitude which they owed to Alexander von Humboldt. Dumas's removal to Paris took place in 1823.

If a legitimate desire to become acquainted with the leading men of science of that day was one of the principal motives in determining Dumas to leave Geneva, his wishes were gratified far beyond his most sanguine expectations. Nothing could have surpassed the kindness with which the young aspirant was received by the very men to whom he had hitherto been looking up with mingled feelings of reverence and awe. As an illustration of the sympathetic interest which the most illustrious *savants* of the period accorded to the labors of their youthful fellow-workers in the field of science, Dumas is fond of describing his own *début* in the Academy of Sciences. Having read a joint paper of his and Prévost's on muscular contraction, he had modestly retired into the embrasure of a window (as would become his age), when a member of the Academy—a veteran with white hair and a most dignified countenance—rose on the other side of the table and walked up to him. "Monsieur Dumas, will you do me the honor of dining with me on Wednesday next?" he asked the astonished young chemist in a most formal manner. Nothing could be more natural than to accept so kind an invitation. After an exchange of a few polite words Dumas's new friend gravely retired to his place, receiving everywhere unequivocal marks of the greatest respect. "With whom am I to dine?" asked Dumas of one of his neighbors. "Do not you know M. de Laplace?" was the answer. And not only did Dumas dine with Laplace, but he learned with lively interest that the illustrious astronomer had retained a sort of passion for physiological inquiries ever since he had jointly worked with Lavoisier on animal heat and respiration.

In 1824 Dumas married Mdlle. Hermine Brongniart, daughter of Alexandre Brongniart, the illustrious geologist, and sister of his friend Adolphe Brongniart. The union was a most happy one. Dumas's career in Paris has been one of remarkable productiveness and brilliancy. His researches in organic chemistry, so thoroughly begun in

Geneva, were resumed and pursued with great ardor. He was the rival of Liebig, who sò successfully cultivated the same field at the same time. But the two chemists, although often in sharp collision in their views, were ever firm, affectionate friends. Of their relation, Dumas remarked as follows :

"To find our way through these unexplored territories, we had neither compass nor guides, neither method nor laws. Each of us had been led to form ideas and to elaborate views peculiar to himself, which he defended with warmth and even with passion, but without any feeling of envy or jealousy. The discoveries to be made appeared to us without limit, and each was satisfied with his harvest. What we both had at heart was to stake the ground and to open roads, nor have I any doubt that, in reading my papers, Liebig felt the same pleasure which the perusal of his afforded me. If a new step had been taken, it was of little moment whether it had been made by the one or by the other, since it served us both on the road to truth." This generous feeling was heartily reciprocated by Liebig, who dedicated the German edition of his "Familiar Letters on Chemistry" to Dumas with the most cordial expressions of high regard.

It is impossible here even to name his scientific conquests. He early propounded new views of the atomic theory, which time has confirmed ; and his experimental inquiries into the compound ethers laid the foundation of that branch of organic chemistry.

Dumas has been both a prolific and an elegant writer. His works present considerable variety, both as to the subjects discussed and to the form of treatment adopted. There are several elaborate treatises and a great many minor pamphlets. His academical notices, his official documents, his municipal reports, his festal speeches, his opening discourses, his commemoration addresses, his funeral orations, are countless, and they are all marked by an unusual degree of literary merit.

When the Republic was established in France, the President, Louis Napoleon, appointed Dumas Minister of Agriculture and Commerce ; and when the Empire was established he became a Senator. His talents were now largely devoted to the public service, and he was the active spirit in numerous commissions in which his extensive and accurate knowledge was invaluable. With the overthrow of the Empire he returned to private life, and again resumed the scientific labors which have ever been his chief delight.

CORRESPONDENCE.

"WHAT THE EYE SEES IN READING."

Messrs. Editors.

IN your admirable cautionary note on "The Eyesight of Readers," in the September number of your magazine, you say, "A book of five hundred pages, forty lines to the page and fifty letters to the line, contains a million of letters, all of which the eye has to take in, identify, and combine each with its neighbor."

I believe you are wrong. I don't believe we deal with letters in reading at all, except when we meet unfamiliar words. I think persons, who read rapidly recognize words and phrases without analyzing them into their elements. I think that every word has a countenance, a physiognomy, which we soon learn, and which we afterward recognize as we do the faces of our friends.

Repeatedly I have amused myself by approaching an unfamiliar sign, or handbill, or printed page. What comes first into view? Not letters, but words; and they stand identified when no single letter can be distinguished.

It lies within easy observation that the lateral oscillation of the eyes of a rapid reader is very limited. Why? He cares so little about spelling the words he reads, that he does not even present to all of them the more sensitive spots on his retinæ, but is content to leave the images of most words upon more peripheral parts where they could not be spelled.

I would not presume to inform you of the brilliant success of the experiment of teaching children to read without spelling—an experiment which I believe has been most thoroughly tried in St. Louis. In the case of children so taught, words only are scanned, the young readers being wholly ignorant of the value of letters.

I have a correspondent whose written characters could not possibly be recognized, and yet to me his letters are fairly legible. Why? Because, however far he departs from the standard of the copy-book, he always writes any given word in the same way; and, although I could not *spell* isolated words from his written page, I have learned to recognize them as quickly as if they were fairly printed.

I think it might be successfully maintained that there actually is not time for each letter to be separately regarded, either by the eye or the mind, in rapid reading. I read the first three pages of the "Sketch of Joseph Leidy" in three minutes, and Abercrombie could have read it much quicker. In each minute I read four hundred words, containing more than two thousand letters. I submit that, while it is possible to see six or seven words per second, it is quite impossible to see thirty or forty letters per second.

DAN MILLIKIN.

HAMILTON, OHIO, *September* 10, 1880.

A CASE OF PROTECTIVE MIMICRY.

Messrs. Editors.

I VENTURE to send you an account of a sparrow's performance which I witnessed some time ago, and which you may consider worth publishing. It seems to me that the publication of such observations, when known to come from a trustworthy source and bearing the stamp of probable correct interpretation, is sure to add a light and pleasant page to our journals of popular science, as well as furnish a store from which illustrations may be drawn by those needing them. You have no reason to know me or my trustworthiness, but, that I do not depend upon imaginary data for such narratives as I send, I think I may refer you to my friend and teacher, Professor W. K. Brooks, of the Johns Hopkins University, or to Professor Martin, of the same institution, although I do so this time without their knowledge or permission.

Some time since, while riding slowly along a dusty macadamized road, I was startled by the hurried flight close by my side of a small bird which dropped in the road a few paces ahead, and after a flutter in the dust sat perfectly motionless. I drew up my horse to watch events, when a moment later a hawk swooped by, but missed its prey, and went off into an adjoining field. The sparrow remained still in its place, and, all covered with dust, looked for all the world like one of the many loose stones in the road—so much so, that no wonder it should have escaped the sharp sight even of the hawk.

But one explanation of such a freak seemed possible; and when we reflect that these birds generally take to the bushes or to the lichen-spotted rail fences, when pursued by hawks, and that dust is not a constant factor of the environment, we stop to admire so bright a spark of intelligence kindled under such trying circumstances.

Respectfully,

BOLLING W. BARTON, M. D.

BALTIMORE, *September* 30, 1880.

A SHOWER OF DUST.

Messrs. Editors.

In your July issue, I find a communication from Mr. Kirkwood, of Bloomington, Indiana, in regard to a deposit of dust that was observed there on the 28th March, 1880, and in which the theory is advanced, to account for its origin, that, since a similar phenomenon occurred in Europe almost simultaneously, both may be of common origin.*

The following is collated from the "Weather Review" (the official organ of the United States Signal Service) for March, 1880, and it undoubtedly leads us to infer that the Bloomington phenomenon and those treated in the "Review" were identical:

No. XV.—This area appeared in British Columbia, the afternoon of the 24th; Portland barometer 0·46, and Fort Benton barometer 0·45 below the normal. Moving southeastward, it was in Idaho the morning of the 25th, and by an easterly path was central in Nebraska the afternoon of the 26th, Omaha barometer 0·75 below the normal; at that time the pressure in the entire Missouri and upper Mississippi Valleys ranged from 0·40 to 0·75 below the normal. At midnight the area was central in Iowa, at which time the pressure over the greater part of the lower Missouri and upper Mississippi Valleys was 0·60 below the normal. At that time brisk easterly winds prevailed in the entire lake-region and Mississippi Valley generally, accompanied by rain, and brisk northerly winds from the Missouri Valley westward. On the morning of the 27th the area was central in eastern Iowa—Davenport barometer 1·04 below the normal—in the afternoon in northern Illinois, and at midnight in northwestern Ohio. During the day violent wind-storms (see data regarding local storms) occurred in the upper Mississippi and lower Missouri Valleys, and in the upper lake-region, westward from the Mississippi Valley to the Rocky Mountain slope, but little or no rain falling; remarkable dust-storms prevailed. Las Cruces, New Mexico, 26th, very violent sand-storm, filling the air with dust. Leavenworth, Kansas, 27th, blinding dust-storm, almost obscuring the sun at 10 A. M. Fort Davis, Texas, violent sand-storm. Ringgold, Ohio, 27th, heavy wind and hail storm. Professor Nipher, of St. Louis, Missouri, reports this storm "as the most remarkable phenomenon of the month. It covered the entire State, except the extreme southern part. The atmosphere was filled, during the whole day, with a fine grayish dust, which, in the western part of the State and in eastern Kansas, was so dense as to obscure the light of the sun, and to render objects invisible at a distance of from one to three hundred yards. The wind was very high, coming in most cases from the west and northwest."

P. F. Lyons.

Leavenworth, Kansas, *July* 28, 1880.

* In our opinion, Professor Kirkwood's letter will not bear this construction.—Ed.

MR. HERBERT SPENCER'S FACTS.

Messrs. Editors.

Allow me to say, respectfully, that Mr. Spencer impairs the public confidence in his conclusions by inattention to the reliability of what he states as facts. It is not enough that an author can cite book and page of some other writer in exact confirmation of his words. Responsibility for the truthfulness of the statement, which is the main thing, must rest upon him who repeats as well as on him who first puts it forth. A teacher of philosophy, especially, is bound to acquire a critical knowledge of the facts he uses, and to employ this knowledge judiciously for the benefit of those he attempts to instruct. In Mr. Spencer's preliminary article upon "Political Institutions," in the October number of "The Popular Science Monthly," the following statement occurs at page 6: "Having great cities of one hundred and eighty thousand houses, the Mexicans had also cannibal gods; . . . and, with skill to build stately temples big enough for ten thousand men to dance in their courts, there went the immolation of twenty-five hundred persons annually, in Mexico and adjacent towns alone, and of a far greater number throughout the country at large."

A few words concerning the *one hundred and eighty thousand houses* in the *pueblo*, not the city of Mexico. There is some difference in the estimates of the population of Mexico found in the Spanish histories, but several of them concurred in the *number of houses*, which, strange to say, is placed at *sixty thousand*. Zuazo, who visited Mexico in 1726, wrote "sixty thousand inhabitants," not houses (Prescott, "Conquest of Mexico," vol. ii, p. 112, note); the anonymous conqueror, who accompanied Cortes, says "sixty thousand inhabitants"—"*soixtante mille habitans*" (A. Tarnaux-Campans, vol. x, p. 92); but Gomara and Martyr wrote "sixty thousand houses," and this estimate has been adopted by Clavigero ("History of Mexico," Cullen's translation, vol. ii, p. 360); by Herrera ("History of America," London edition, 1725, Stevens's translation, vol. ii, p. 360), and by Prescott ("Conquest of Mexico, vol. ii, p. 112). Solis says "sixty thousand families," instead of houses or inhabitants ("History of the Conquest of Mexico," London edition, 1738, Townsend's translation, vol. i, p. 393). This guess would give a population of three hundred thousand, although London at that same time, after centuries of growth, contained but one hundred and forty-five thou-

sand inhabitants (Black's "London," p. 5). Finally, Torquemada, cited by Clavigero (ib., vol. ii, p. 360, note), boldly writes "one hundred and twenty thousand houses"; and now Mr. Spencer not only calls this Indian *pueblo* a "great city," but informs us that it contained "one hundred and eighty thousand houses." Torquemada had doubled the first estimates, and Mr. Spencer not only accepts the doubling, but adds upon some special authority an extra "sixty thousand houses," thus showing a tendency of mind to adopt the most extravagant views, where degrees exist. At five inmates to each house, it would give nine hundred thousand inhabitants. No doubt Mr. Spencer can furnish an authority of some kind for his "one hundred and eighty thousand houses," but that would not mend the matter, as the statement is simply so preposterous that Mr. Spencer is without excuse.

Nor is this the end of the difficulty. There can scarcely be a doubt that the houses in this *pueblo*, like those of the Indian tribes in New Mexico, and in Yucatan and Central America of the same period, were generally large joint-tenement houses, large enough to accommodate from ten to fifty and a hundred families in each. This, if true, raises the absurdity to the maximum point. Zuazo and the anonymous conqueror, who stated the population of Mexico at "sixty thousand persons," came the nearest to a respectable estimate, as they did not more than double the probable numbers.

I will say nothing of the annual number of human sacrifices stated at "twenty-five hundred in Mexico and adjacent towns," and, "far more than twenty-five hundred in other parts of the country," nor of the ten thousand dancers, who could dance in the courts of the great *teocalli*. By this carelessness concerning his statements, to put it in the mildest form, Mr. Spencer will inevitably draw and write upon some of his later works the old charge, *falsus in uno falsus in omnibus*.

M.

A MINIATURE CYCLONE.

Messrs. Editors.

The cyclone which visited a section of Montgomery County on the afternoon of the 3d of September, 1879, although insignificant in its extent and destructive power, when compared with some of those which occasionally ravage other regions of the country, possessed certain features that render it worthy of study. Its dimension and effects were such as to bring it within the compass of close examination, enabling the observer to view the phenomenon as a whole. It was a perfect little cyclone in itself, with the conflicting currents, the roaring noise, the numerous distinct whirls and the double cones in the air, with the uprooted trees on earth, all presenting a combination of features whose investigation may lend important assistance to the student of these universally interesting catastrophes.

A paper on this subject was read at one of our meetings, presenting such facts as had come at that time under the observation of the writer. Having made further explorations in conjunction with a friend who is also much interested in the phenomenon, we are prepared by a visit of inspection over the whole course of the storm, from its origin to the place of final disappearance, to make a statement of the principal facts just as they were seen.

The tree, which appears to have been the first object struck by the tempest, stands in the edge of a field prepared for sowing wheat, and covered with piles of manure. This tree was not uprooted, but the limbs were much blown about, some of them twisted round the main stem, and the singular appearance was presented of strands of manure blown into slight crevices of the trunk—sucked in, as it were, up to the height of fifteen or twenty feet; the heaps of manure were of course widely scattered.

Coming out of the field referred to, the storm fell in its fury on a family graveyard. Two large tombstones, ten feet apart, secured by iron pins let into an horizontal stone slab, were thrown flat in opposite directions, the one to the east and the other to the west of the path of the storm. The tombstones were three feet high, two feet wide, and six inches thick, weighing over three hundred pounds each. The general width of the current at this place appeared to have been about forty yards; but a tree one hundred yards east of the graveyard was much broken. Passing next through a corn-field, where the stalks in the middle lay in the direction of the path, and those at the edge leaned generally toward the center, on into a potato-patch, where some of the vines were blown out of the ground, bringing the tubers with them, the tufted weeds sharing the same fate, the winds, truly winged, vaulted over the fence without disturbing a rail, or the trees of a wood in their course for a space of some sixty yards. Then the whirling current descended, prostrating some trees as it entered a field, where it leveled the grass as if a roller had passed along, and made three distinct shallow holes in the ground, at least a foot in length. A few stones lying near, out of their previous place, appear to have been used by the wind as an agent in digging these holes.

After leaving this field, there was an interval of perhaps half a mile in which were but slight traces of the storm. It then swooped down upon a forest thick with large trees, a number of which were uprooted, lying in different directions, and others with their upper limbs and tops much twisted

and broken. Leaving this, the cyclone fell into a meadow, then rose, and, after a course of a few hundred yards, it descended upon an elevated section of forest. Here, about the middle of its course, the destruction was most apparent, in the way of uprooted and broken timber; and so unconformable was the lay of the prostrate trees, as to defy all the ordinary theories of cyclones.

But this spot afforded clear evidence of the successive ascent and descent of the whirling current as it swept along; for the trees where it entered the forest had only their tops and upper limbs twisted and mutilated, a series of whole trees uprooted following in the path, while again the destruction was confined to the top at the place where the storm left the woods.

The next remarkable object was a cornfield, in which the damage was conspicuous. The stalks were stripped and some blown out of the ground. The earth looked as if scraped by some hard substance. A tenant-house was next on or near the route, but the damage was slight; a shutter was blown away, only pieces of which could be found. A bed in this house was blown against the window. Farther on, a stable was partly unroofed, and a corn-house lifted up from the piers that supported it, transported a few feet, and so gently deposited that a full hogshead of wheat uncovered was let down without spilling more than a few grains. The alarmed owner found himself unable to open the door of his house. Thus far the force of the storm had been directed only against trees of the forest; it now struck the orchards of two adjoining farms, leaving sixteen fine apple-trees prostrate.

In one of these, the trees were strewed on the ground almost in the direction of the spokes of a wheel. For the next half mile very little damage was done, the path being marked by a few broken limbs of trees. But the storm came down once more, and uprooted a number of large trees, quite in a valley.

Its violence was now exhausted; we followed the path with some difficulty half a mile farther, and then no more traces of it were to be found.

The cyclone, after a course of about five miles, ascended and dissolved away into the upper air. No part of the phenomenon was more clearly indicated than this alternate descent and rise of the whirling column as it moved along. This was manifest not only from observation of the objects on the route, but was plainly seen by persons who watched the current from neighboring hills. Filled with dust and leaves and boughs of trees, and distinctly colored, the contiguous separate whirls formed a spectacle of terrible grandeur as seen from elevated points at a distance. There were slight occasional zigzags in the route, but for the most part it was remarkably direct, with a course bearing about ten degrees east of north, and a width varying from thirty to seventy yards.

In regard to the velocity of the current, no precise estimate can be made. The nearest approach to it would be to say that the course of five miles appears to have been accomplished in about five minutes.

Two facts afford some indication as to the dimension of the whirls that were continually forming and changing in the progress of the cyclone. In the case of the orchard-trees, described as lying somewhat in the form of spokes of a wheel, the diameter of the whirl must have been about thirteen yards, while in the graveyard it could not have exceeded ten feet.

Some persons heard, during its progress, what they liken to explosions. Some also heard a noise resembling the roar of a railroad train, before it began its course below.

Immense cumuli clouds were piled up over the storm-clouds, their brightness contrasting strongly with the black and threatening appearance of the latter.

William Henry Farquhar.
Henry C. Hallowell.

Rockland Sandy Springs, Maryland, *March* 24, 1880.

EDITOR'S TABLE.

SIR JOSIAH MASON'S SCIENCE COLLEGE.

SIR JOSIAH MASON, the founder of a new Science College, in Birmingham, England, is an old gentleman of eighty-six who has considerable reputation as a rich philanthropist. He amassed an immense fortune by the manufacture of a steel pen of famous reputation and by the business of electro-plating. He spent large sums in establishing hospitals, asylums, and almshouses, and endowing them for the benefit of deserving persons in want; and, among other public charities, he built and endowed an orphanage capable of receiving, educating, feeding, and clothing five hundred orphan children

who were to be helped without regard to their nationality or religion. His last great benefaction is the establishment and the equipment of a Science College, "to provide for a thorough systematic education in science with a distinctly practical application to the industries of the Midland district and particularly to those of Birmingham (in which the founder has spent the greatest portion of his life), and of Kidderminster, where he was born."

Two courses of study are provided for in the deed of foundation. The course of regular systematic instruction is to be of such a kind as shall qualify students either for passing the examinations necessary to obtain the degrees of Bachelor of Science, or of Doctor of Science, of the University of London; or for any profession or pursuit in which scientific knowledge can be usefully applied. Besides this there is a course of popular instruction in the practical applications of science which it is intended shall be given by means of evening lectures to artisans and others who can not attend the classes of regular systematic instruction. All departments in the college are open to both sexes on the same terms. The faculty consists of able men carefully chosen, and the institution was opened October 1st, with an introductory address by Professor Huxley on "Science and Culture," which is herewith reprinted.

Professor Huxley's interesting discourse was well suited to signalize the occasion which called it forth; but on the other hand there was that in the occasion which gave a telling emphasis to the discussion. The Mason College was put upon a new basis. It was to be broadly devoted to science, and, to prevent interference with this distinctive and comprehensive purpose, its founder excluded "theology," "party politics," and "mere literature" from its scheme of studies.

In thus constituting his college, Sir Josiah Mason must be regarded as representing a pronounced tendency of the age. But the theory of education embodied in his institution was the result of extensive practical intercourse with the common people, and an intimate knowledge of their real wants. He was not an enthusiastic scientific student, run away with by a hobby, but a cool-headed observer of affairs, and the bold ground that he took testifies to both his sagacity and his independence. The founders of colleges and universities are usually ambitious to enlarge their schemes of study, so that "all knowledge" may be obtainable within their precincts. Sir Josiah Mason had the good sense to recognize that, in all such attempts, traditional and fashionable studies will usurp the places of those that are really far more valuable; so he determined to keep out those subjects which would hinder instead of promoting scientific proficiency. It was a plucky thing to do in England, where the reverence for old classical literature amounts to a superstition, while acquaintance with it is held as the sole test of a liberal education.

It would probably not have made much difference what educational absurdity an old man might have perpetrated, as he was himself unlettered, and his college was to be a mere vulgar, useful knowledge dispensatory for working people. But when Professor Huxley came forward and endorsed the wisdom of the founder, and when, moreover, he began to talk about a new and higher type of culture, the offspring of modern thought, and grounded upon science, there were at once symptoms of perturbation and perplexity in the literary circles. There was not, as there could not be, any intelligent controversy with the Professor over the positions he took; but the proprieties had been shocked, and the real question was, where *did* Huxley stand, and what *could* the man mean? His concessions, as the reader will see, were large, but that availed little, if he denied the exclusiveness of the

old university ideals of culture. The whole pinch is here, for, whenever science is recognized as the foundation of a valuable and desirable mental culture, the progress of thought will soon give it the supreme place as a means of the higher education.

CURIOUS EDUCATIONAL LOGIC.

The rapid development in this country of a vast system of state education, under the control of politicians, gives interest to the views of those men on the subject of educational philosophy. President Hayes in his speech, which we referred to last month, is reported to have made the following remarkable statement: "The unvarying testimony of history is that the nations which win the most renowned victories in peace and war are those which provide ample means of popular education." That is, according to the President of the United States, popular education is equally a preparation for victories in peace and victories in war—the destructive practice of savages and the constructive vocations of civilized life. It has been the inspiring hope of multitudes through many ages that the world would yet outgrow the brutal pursuit of war, and they have had faith that this great result would be ultimately achieved by the progress of general enlightenment and the development of the arts of peace which communities would find it for their highest interest to promote. It has been believed that the victories of peace would put an end to the curses of war, because the state of mind they would engender in society must be incompatible with military barbarism. Certainly, if there is deadly antagonism anywhere it is between the interests of war and the interests of peace; but President Hayes seems to think popular education has the marvelous capacity of leading both ways, to triumphant war and victorious peace.

We need not go far for illustrations of inveterate hostility between the interests of peace and war, and for the influence of this conflict in shaping the permanent policy of government. The antagonism casts its malign shadow over all the periods of peace. The commerce and industry of the country are "regulated," not by the intrinsic laws of commercial and industrial prosperity, but with reference to the alleged contingencies of future war. Why should the intercourse of nations be impeded by shackles upon trade? Why should private enterprise be thwarted, and the intelligence of citizens discredited in regard to the course of industrial occupation? Because at some future time we may want to fight the world, and so must keep ourselves independent of it. We are cursed with a war-tariff because we had a domestic war, and must continue it because we may have foreign wars; and thus citizens are coerced this way and that in all their most vital private interests by the predominance of the military spirit.

A more specific illustration is fresh in the minds of all. The opening of a canal at the Isthmus of Darien would be one of the greatest victories of peace in the interest of the world that has ever been accomplished. It would bind the nations in pacific restraints more powerfully than any other international measure ever proposed. But it was resisted in this country in the interests of future war; and President Hayes and the politicians of Congress did all they could to prevent the execution of the work by a disgraceful demagogical perversion of the Monroe doctrine. The popular education of the politicians did not here lead them both ways, according to Hayes's formula; they sacrificed the victories of peace on the pretext of the adverse interests of future war.

President Hayes invokes "the unvarying testimony of history" to establish his proposition, but the problem of the influence and effects of "popular

education" is hardly yet historical. Not many "nations" have gone far into the experiment; those which have done so are recent, and the results by no means confirm President Hayes's conclusion. Prussia leads in popular education, and that education is tributary, not to the victories of peace, but to the victories of war, the first fruit of which is a grinding military despotism. The popular education of Germany, moreover, exemplifies in a marked degree the antagonism we have referred to, and is wholly subordinated to military ends. The following remarks of Professor Dabney, in a late number of the "Princeton Review," bear decisively upon this point: "Recent history is more instructive, because it offers us illustrious experiments of popular education carried for two generations as far as it is ever likely to be carried. Our overweening hopes of good from mere mental culture are much curtailed by observing that the condition of Christendom was never more ominous and feverish than it now is, after these efforts at education. Military preparations were never so immense, or so onerous to the national industry. The spirit of war was once ascribed to the ambition of kings, regardless of the blood of their peace-loving subjects. But we now see that, since the instructed peoples have acquired influence in the governments of Europe, this fell passion is more rife than ever. It seems, moreover, that the German nation, the most educated one of all, is in as unstable a condition as the rest. The wildest political heresies prevail; and these rulers, the special and boasted exemplars of popular education, rely least on popular intelligence, and most on the sword, to save society from destruction. Intelligent men there dismiss the idea with ridicule that any actual diffusion of intelligence among the peasantry, by the schools, is the real safeguard of their universal suffrage. They tell us that not one in three exercises his accomplishment of reading when an adult—a statement which the scanty circulation of newspapers among them confirms. They say that the primary schools are useful chiefly as *a drill in obedience.* They teach the child early to submit to superiors, to move at the sound of a bell, to endure tasks, to fear penalties, to study punctuality, at the command of others. Then comes the conscription, and seven years' drill in arms, to confirm the habit of submission. Thus the German system produces a peasant who is in the habit of voting as the upper classes bid him, not of thinking for himself! It is presumed that this picture of the virtues of the system is not very flattering to our American hopes."

DR. EDOUARD SEGUIN.

In the death of Dr. Seguin, which occurred October 28th, the community has lost a man of genius and also of peculiar and eminent usefulness. Though a physician, and devoting himself to a specialty in his profession, the results of his studies are of very broad application, and are sure to be increasingly appreciated in the future.

Dr. Seguin was born at Clamecy, in France, in 1812, studied medicine and surgery in Paris, and early devoted himself to the investigation of nervous diseases, and particularly to the nature and treatment of idiocy. When he took up the subject of the education and training of the weak-minded, it had been but very little explored; there was profound and widespread ignorance of all its principles, and it was hedged about by inveterate prejudices and superstitions. In the seventeenth century St. Vincent de Paul gathered a few idiots and labored assiduously for years to instruct them, though with very little success. In 1799 Jean Gaspard Itard, an eminent French surgeon and a disciple of Condillac, grappled with the problem in the case of the

"wild boy of Aveyron." This was an idiot found in the forests of Aveyron, and who was taken up by Itard for the purpose of solving "the metaphysical problem of determining what might be the degree of intelligence and the nature of the ideas in a lad who, deprived from birth of all education, should have lived entirely separated from the individuals of his kind." The philosophy of the time was consonant with its theology; for, while theology taught that man is fallen from a primitive state of paradisaical innocence, philosophy held that he has fallen away from the perfection of a "state of nature." Hence there was great curiosity to find out what would be the state of mind of one who had not been perverted by association with civilized people. Nothing, of course, came of Itard's experiment, except that he had got hold of an idiot of low grade, and satisfied himself that it might be possible to improve such natures in some small degree.

Dr. Seguin was a pupil of Itard (who lived till 1838), and, receiving from his teacher the facts and results that he had gathered, young Seguin entered systematically upon this line of study. The subject was beset with great difficulties, and the young Frenchman entered upon it with enthusiasm as a labor of love, and devoted several years to a thorough research into the causes and philosophy of idiocy and the best methods of dealing with it. As the investigation was a practical one, Dr. Seguin organized schools in connection with public institutions and also under private control; and it was the successful results in these establishments which became the basis of his numerous publications on his chosen subject. In 1839 he published, in connection with the celebrated alienist Esquirol, his first pamphlet; and in 1846 he put forth an elaborate treatise expounding his system of the treatment of the idiotic and weak-minded. This work became at once the authorized text-book of the subject, and placed its author in the front rank of living physiological psychologists.

Dr. Seguin came to this country in 1848, and resided for ten years in Ohio. He then returned to Paris, but came back in 1862, and has lately resided in New York. He continued his observations and inquiries on the subject of idiocy in this country, and organized several institutions devoted to their care and training. He, moreover, had the satisfaction of seeing the rise of a great number of schools for the feeble-minded and lowly organized, which adopted his methods of cultivation with remarkable success. To him, in fact, more than to any other man, belongs the immortal honor of showing to what a degree the badly-born—the congenital failures of nature—can still be redeemed and elevated to comparative usefulness. How much has been thus gained by the combination of scientific knowledge and skillful, persevering art is thus stated by Professor Seguin himself: "Not one in a thousand has been entirely refractory to treatment; not one in a hundred who has not been made more happy and healthy; more than thirty per cent. have been taught to conform to social and moral law, and rendered capable of order, of good feeling, and of working like the third of a man; more than forty per cent. have become capable of the ordinary transactions of life under friendly control, of understanding moral and social abstractions, of working like two-thirds of a man; and twenty-five to thirty per cent. come nearer and nearer to the standard of manhood, till some of them will defy the scrutiny of good judges when compared with ordinary young women and men."

Dr. Seguin was the author of many publications, the last of which was the second edition of his "Report on Education" as United States Commissioner at the Vienna Universal Exposition. We noticed this report upon its first appearance, but a revised edition appears

this year from the press of Doerflinger, of Milwaukee, Wisconsin. This little volume is of much interest to educators. It treats the subject by the physiological method, which is the point of view to be taken in the education of childhood. Part I is devoted to Infant Education, the Kindergarten, and what are called Physiological Infant Schools. Part II considers the Education of Deaf Mutes; Part III the Education of Idiots; and Part IV applies the results arrived at to Popular Education as it is and as it should be. The book is full of valuable information and pregnant suggestions, taking their complexion from the author's professional experience, scientific observations, and peculiar line of studies.

We began by remarking that Dr. Seguin's special studies have a breadth of application that reaches far beyond the technical schools for the feeble-minded. He has taught the world the difficult task of elevating idiots into rational beings. An intelligent appreciation of his philosophy might at least prevent us from doing the opposite—turning rational beings into idiots in our popular schools. If any are curious about the *rationale* of this process, we refer them to the article on "The Artificial Production of Stupidity in Schools," in the second number of "The Popular Science Monthly."

LITERARY NOTICES.

Odontornithes: A Monograph on the Extinct Toothed Birds of North America. With Thirty-four Plates and Forty Woodcuts. Forming Vol. VII of the Geological Survey of the Fortieth Parallel. By Othniel Charles Marsh, Professor of Paleontology in Yale College, New Haven, Conn.

Fossil anatomy is generally regarded as one of the driest of subjects; but, when the vestiges of old bones become the keys to the history of the world and the mysteries of the universe, their study acquires an intense interest. No better exemplification of this can be found than that furnished by the author of the splendid monograph before us. Professor Marsh, as is well known, has been engaged for the last ten years in exploring the Rocky Mountain regions in search of fossils, and his enthusiasm, untiring energy, and whole-souled devotion to the work well attest the fascination there is to the scientific mind in inquiries which the mass of people are apt to regard with indifference.

Two circumstances combined to give especial and powerful interest to the investigation. The region was rich in new material for paleontological science, and the facts discovered were certain to have great significance in their bearing upon biological theory and our whole view of the economy and order of nature.

Geology tells us, in the first place, that the North American stratified rocks, over vast areas west of the Mississippi, were deposited in a continuous, tranquil way, and were so little disturbed by revolution and upheaval that the formations are found in a remarkably unbroken sequence. The geological systems follow each other regularly, so that the record is in an unusual degree complete. But, while the strata under the vast prairies remain nearly horizontal as they were left by deposit and subsidence, the beds have been denuded, and thrust up here and there so that the outcropping strata are open to examination. The maximum thickness of these formations is estimated at some seven or eight miles, and the "stratigraphical succession" is so perfect as to be most favorable for the study of the order and dependence of the extinct forms of life. Thus the field was not only fresh, but propitious for new paleontological exploration. In the second place, this interest was heightened by the crisis of biological speculation. The theory of the continuous evolution of living forms by descent with variation had got a foothold with naturalists, but evidence was sorely wanting to supply the missing links in the chains of organic succession. There was a demand for "intermediate types," and that the connecting forms predicted by the evolutionists should be forthcoming. The research had a factitious interest from these circumstances. Professor Marsh was, of course, animated by the genuine scientific motive of finding

out the facts, whatever theories they might favor; but he could not be insensible to the import of his labors.

Some idea of the immense value of Professor Marsh's contributions to paleontology, as well as the immense labor that they have cost, may be gathered from the fact that in the last twelve years he has enriched the museum of Yale College alone with about one thousand *new species of extinct vertebrates*, at least one half of which remain to be studied out and described. That which is remarkable about these collections is the excellence of their preservation, and the profusion of specimens by which it becomes possible to restore nearly completed skeletons. Paleontologists have hitherto had to work much from fragmentary specimens; but Professor Marsh is now enabled to restore the extinct vertebrate forms of the Western Cretaceous beds with such fullness of detail as seriously to affect the literary treatment of the subject. His large memoirs will be confined to a few restorations, but the work in each case will be a finished contribution to which little can ever be added.

The present memoir on "Extinct Toothed Birds" is his first systematic publication on the Western fossils, and forms Volume VII of the "Geological Survey of the Fortieth Parallel," conducted by Mr. Clarence King; and it also forms Volume I of "Memoirs of the Peabody Museum of Yale College." In regard to its contents, we can not do better for our readers than to reproduce the following extract from a notice of it in "Nature," by Professor Geikie, the able head of the Geological Survey for Scotland:

Among the organic wonders of which from time to time during the past decade announcements have appeared, none have been received with more interest than the discovery of birds with teeth, made by Professor Marsh near the end of the year 1870, in the middle Cretaceous rocks, which in Kansas and Colorado spread out eastward from the base of the Rocky Mountains. So perfect a matrix do the peculiar buff, chalky, or marly beds of the Kansas middle Cretaceous formations furnish for the preservation of organic remains, that almost every bone of the skeletons of some of the birds has been recovered. The material for the study of their osteology is thus almost as ample as that for any living bird. Full advantage of this abundant store of material has been taken. The cases and cellars in the Peabody Museum at New Haven contain the remains of about fifty different individuals of a single bird. Every bone of its skeleton, with the exception of one or two terminal toe-bones and the extreme point of the tail, has been recovered, and is here carefully drawn of the natural size. Never before has it been possible, we believe, to reconstruct so perfectly so ancient an organism.

The volume is divided into two parts. In the first of these the detailed structure is given of the bird on which the author has bestowed the name of *Hesperornis*. The skeleton of this animal if extended to its full length would measure about six feet from the point of the bill to the end of the tail. It must have been a typical aquatic bird, without any power of flight, but with strongly developed limbs and a long, flexible neck, whereby it was doubtless endowed with remarkable powers of diving and swimming, and of seizing the abundant fishes of the shallow seas in which it lived. Compared with our modern birds, the two features of this ancient form which most forcibly arrest attention are the teeth and the legs. The teeth were covered with smooth enamel, terminating upward in conical pointed crowns and downward in stout fangs, closely resembling those of mosasauroid reptiles. Their mode of growth and replacement have been determined to have taken place in a manner very similar to that in some reptiles, the young tooth forming on the inner side of the fang of the tooth in use, and increasing in size, while a pit for its reception was gradually made by absorption. The old tooth, being progressively undermined, was finally expelled by its successor, the number of teeth thus remaining unchanged. The teeth were implanted in a common alveolar groove, as in *Ichthyosaurus*. In the upper jaw they were confined to the maxillary and entirely absent from the pre-maxillary bone; in the lower jaw they extended from near the anterior extremity of the ramus along the entire upper border of the dentary bone. Mr. Marsh believes that they were held in position by cartilage which permitted some fore-and-aft movement, but on the decay of which after death the teeth readily became displaced and fell out of the jaw. This is an important fact in its bearing upon the nature of the teeth found on the same slab of Solenhofen limestone with the well-known *Archæopteryx*. These teeth, it will be remembered, were referred by Mr. Evans to the bird itself—a reference fully confirmed by Mr. Marsh, who says that he at once identified the teeth as those of birds and not of fishes, and by the subsequent discovery of other remains of the bird. In *Hesperornis regalis* there appear to have been fourteen functional teeth in the maxillary bone, and thirty-three teeth in the corresponding ramus of the lower jaw. The wings are rudimentary or aborted, a remnant of the humerus alone existing. They may have gradually diminished from disuse until, as the power of flight ceased, the legs and feet increased in proportion, and assumed the massive dimensions shown in these specimens, or, as Mr. Marsh suggests, the bird may have been a carnivorous aquatic ostrich, never having possessed the power of flight, but descended from a reptilian ancestry, which is strongly

recalled by different portions of the skeleton. Among recent birds, the peculiar legs and feet of *Hesperornis* find their nearest analogues in the Grebes of the genus *Podiceps*. They were admirably adapted for propulsion in water, but scarcely served for walking on land. Locomotion must have been entirely performed by the posterior limbs—a peculiarity which distinguishes *Hesperornis* from all other aquatic birds, recent or fossil. The tail appears to have been composed of twelve vertebræ, unique in their peculiar, widely-extended, transverse processes and depressed horizontal plowshare bone. Broad and flat, somewhat like that of the beaver, it must have been a powerful instrument in steering the bird through the water.

The second part is devoted to a description of the remains which have been found of birds belonging to a second order of Odontornithes, termed *Odontotormæ*. Unlike *Hesperornis*, they seem to have been all of comparatively small size and to have possessed powerful wings, but very small legs and feet. From that contemporaneous form, and from all other known birds recent and fossil, they are distinguished by certain types of structure which point back to a very lowly ancestry, lower even than the reptile. Their bones, being mostly air-filled, would enable the carcasses to float on water until, by decay or the rapacity of other animals, they were separated and dispersed. Hence skeletons of these flying birds are less entire than those of the massive-boned *Hesperornis*. Nevertheless, the remains of no fewer than seventy-seven different individuals have been disinterred. These are included in two well-marked genera, *Ichthyornis* and *Apatornis*, and were all small birds, reminding us by their strong wings and delicate legs and feet of the Terns, like which they were probably also aquatic in habit. Besides the reptilian skull and teeth, the birds of this second order were marked by the character of their vertebræ, which in their biconcave structure recall those of fishes. This is the more remarkable, as in *Hesperornis* the vertebræ are like those of modern birds. Yet these two utterly dissimilar types were contemporaries, and their remains have been preserved in the same strata. Mr. Marsh points out that the transition between the two vertebral types may be traced even in the skeleton of *Ichthyornis* itself, where the third cervical vertebra presents a modification in which the ordinary avian saddle-shaped form appears as it were in the act of development from the biconcave ichthyic form.

This memoir and those which will succeed it have a weighty interest as contributions to the doctrine of organic evolution. There is no other possible way of explaining the numerous facts than by this theory. Professor Marsh's discoveries are new demonstrative proofs of the law, which he has done more to confirm by these fossil revelations than any other living man, or all contemporary naturalists put together.

It remains only to add that the volume in all its elements—paper, printing, drawing, and engraving—is superb. The illustrations, all executed in New Haven, and by the most skillful hands the world affords, are the perfection of art. Professor Geikie pays them the following high but deserving compliment: "They are strictly and rigidly scientific diagrams, wherein every bone and part of a bone is made to stand out so clearly that it would not be difficult to mold a good model of the skeleton from the plates alone. And yet, with this faithfulness to the chief aim of the illustrations, there is combined an artistic finish which has made each plate a kind of finished picture." Should the series of memoirs of the Peabody Museum of Yale College, of which this is the first, be carried out on a scale and with a thoroughness here attained, it will form one of the great scientific monuments of the century.

German Thought. By Karl Hillebrand. New York: Henry Holt & Co. 1880. Pp. 298. Price, $1.75.

In these six lectures before the Royal Institution of Great Britain, Professor Hillebrand has traced in outline the rise of modern German thought and its influence in forming modern German political life. The period covered by his review is that from the Seven Years' war to the death of Goethe, but he glances briefly at the part taken by the other nations in the work of modern culture, as an indispensable preliminary to the subject proper. His review leads him to a consideration of the Italian Renaissance, in which Italy led the way in breaking from the thralldom of mediæval tradition and authority; the reaction against the sensuous view of life that this introduced, which in Spain was expressed by the founding of the Society of Jesus, and in Germany by the Reformation; and the passing to England and Holland, and later to France, of the leadership in the thought and spirit that have made modern Europe. Though Germany held an important place in the initial movement, she took but little part, Professor Hillebrand points out, in the subsequent progress of it. She had been engaged in one of the most notable struggles in history, and came out of it prostrate. The Thirty Years'

war not only left her in entire intellectual, moral, and material poverty, but it completely broke the thread of her history, and threw her back full two hundred years. It was not until 1760 that she began "to react against the too absolute thought of France, and to begin the work of restoration on a sounder basis than that which Spain had tried to lay two centuries before." Her restoration was due to two things—the Prussian state and the Protestant religion. The one has gradually molded out of an heterogeneous mass of petty principalities a powerful state, and the other awakened thought, and furnished the conditions in which free inquiry could thrive. The impulse to a large intellectual life came from without, but, once given, a literature grew up which has expanded into a rich and varied product. It has now become national in its tone and feeling, but at first it was purely individual. It is the peculiarity of German literature that it arose, not, as in other countries, after a coherent state had been formed, but before, while yet the nation did not exist, and Germany was but a collection of petty states. It had the task not only of responding to a national spirit, but of forming that spirit. At first, as Germany began to recover from the prostration of its protracted war, the literature was but a soulless copy of foreign models, but with time it grew to be more and more national, and under the impulse of the Seven Years' war it took definite form, and prepared the ground for the generations of great writers which have finally placed Germany abreast of the other foremost nations of Europe. The three generations of writers who did the great literary work of Germany were those born in the sixty-five years from 1715 to 1780, and which followed each other at periods of twenty years. In the first were Klopstock, Wieland, Winckelmann, Kant, Mendelssohn, and Lessing; the second included Herder, Voss, Klinger, Bürger, Goethe, and Schiller. The third and final generation gave to Germany the two Schlegels and the two Humboldts, Rahel, Tieck, Schleiermacher, Niebuhr, Savigny, and Schelling. The "two schools," says Professor Hillebrand, "which from 1825 to 1850 influenced the German mind most powerfully, the school of Hegel and that of Gervinus, only continued, developed, summed up, applied, or contradicted the main ideas of the three preceding great generations." The period of the first two generations was the creative one, when Lessing and Kant, Herder and Goethe and Schiller were leading German thought into new channels. The later period—that of the Romanticists—was essentially a reactionary one, a period in which the middle ages became the ideal. It was, however, a necessary one, and under its influence the past of Germany was brought into prominence, and this prepared the later generation for the constructive work of organizing the German state and arousing the feeling of patriotism essential to its success. When this task has been fully accomplished, Germany can again take up the work of intellectual progress and occupy her place in the general movement of European thought. Professor Hillebrand writes in a very agreeable style, and, though he is confined to a brief outline, he invests his subject with an interest that is sustained to the end.

The Elementary Principles of Scientific Agriculture. By N. T. Lupton, LL. D., Professor of Chemistry in Vanderbilt University. New York: D. Appleton & Co. Pp. 107. Price, 50 cents.

This little primer of agriculture for the public schools had the following origin: The Legislature of Tennessee passed a law authorizing the Superintendent of Public Instruction and the Commissioner of Agriculture to procure the preparation of a suitable elementary work on agricultural science, to be used in the common schools of that State. The Commissioner selected Dr. N. T. Lupton, Professor of Chemistry in the Vanderbilt University, to prepare the book, and this little volume is the result. As our public schools are constituted, it is perhaps as good an introductory book as could be got upon the subject. It is written in a clear and easy style, with the smallest possible amount of technical scientific talk that is consistent with a rudimentary exposition of agricultural principles. After some appropriate opening remarks on the development of scientific agriculture, the author takes up the origin, composition, and classification of soils, the composition of plants, the composition and properties of the atmosphere, and

the sources of plant-food and how it is obtained. This is the most purely scientific part, as all the explanations depend upon chemistry. The author then takes up the questions of the improvement of soils, the use of manures, mineral fertilizers, rotation of crops, and the selection and care of live-stock. This is the more practical portion of the book, and is full of well-digested information which should be got early into the heads of farmers' boys. There is an appendix describing a few simple experiments, and then the customary questions to aid the teacher in the recitations.

Summer-Land Sketches, or Rambles in the Backwoods of Mexico and Central America. By Felix L. Oswald. With numerous Illustrations. Philadelphia: J. B. Lippincott & Co. Pp. 425. Price, $3.

This is a book of travel, adventure, and observation in a wild and picturesque region, upon which pen and pencil have been hitherto but little employed. It is besides a scholarly study of the scenery, the natural objects, the art-works, and the habits and characters of the people that were met with, and it is full of acute reflections and an instructive philosophy thoroughly imbued with the modern scientific spirit. Its style is, moreover, vivid, racy, crisp, and lively, so that altogether the work may be commended to the reader as fresh, original, brilliant, and solid.

Dr. Oswald was stationed at Medellin, near Vera Cruz, in 1867, as director of a military lazaretto. Transferred afterward to the Vera Cruz City Dispensary, he lost his health, and, having got a notion that the mountains of Mexico have great sanitary claims, he resolved to go there and if possible reëstablish his constitution. He rambled about for several years, and this volume is one of the results of his experience. Dr. Oswald has very decided views in regard to some of the evil tendencies of civilization, and was very happy in the great region that has not yet been invaded by the destructive agencies of civilized life.

The following extract from his introduction, shadowing forth this idea, explains the production of the book, and illustrates the characteristics of the author's writing:

In the course of the next eight years I explored the highlands of Jalisco, Oaxaca, Colima, and Vera Paz for the benefit of my own health or that of my employers, but, like the Catalan farmer, I found more than I sought. Independence, in the political sense, and a healthy climate, might be found in the mountains of Scotland, and even of Old Spain; but the new Spanish sierras can boast of a virgin soil, with primeval forests which offer a sanitarium to all who seek a refuge from the malady of our anti-natural civilization —from the old *marasmus* which has spread from the Syrian desert to the abandoned cotton-fields of Georgia and Alabama.

We vaunt our proficiency in the art of subjugating Nature, but in the New World the same ambition has led to a very dear-bought victory, which the countries of the East have paid with the loss of their manhood; their wild woodlands have been tamed into deserts, and their wild freemen into slaves; the curse of the blighted land has recoiled upon its devastators. In our eagerness to wrest the scepter from our Mother Earth, we have invaded her domain with fire and sword, and instead of increasing the interest of our heritage we have devoured the principal; the brilliant progress of the vain god of earth is tracked by a lengthening shadow—the day-star of our empire is approaching the western horizon.

Where shall it end? Mold, sandy loam, and sand, is Liebig's degeneration scale of treeless countries; the American soil may pass through the same phases, and what then? Will the sunset in the West be followed by a new Eastern sunrise? Shall Asia, the mother of religions, give birth to an earth-regenerating Messiah, whose gospel shall teach us to recognize the physical laws of God? Or shall the gloaming fade into the night of the Buddhistic Nirvana, the final extinction of organic life on this planet? It is not much of a consolation to think that in the latter case the nations of the higher latitudes might count upon a protracted twilight. The westward spread of the land-blight will drive the famished millions of the Old World upon our remaining woodlands, but the resources of the last oasis will probably be husbanded with Scotch canniness and Prussian systematism, and before we share the fate of the Eastern nations we may see the dawn of the bureaucratic millennium, when all our fields shall be fenced in with brick walls, all rivers with irrigation-dikes, and all functions of our domestic life with official laws and by-laws. My trust in the eternal mercy of Providence lets me expect another deluge before that time; but the recuperative agencies of unaided Nature seem powerless against the greatest of all earthly evils. National and territorial marasmus are incurable diseases; the historical records of the Eastern Continents, at least, prove nothing to the contrary. The coast-lands of the Mediterranean were the pleasure gardens of the Juventus Mundi, the Elysian Fields whose inhabitants celebrated life as a festival; and now? Spain, southern Italy, Turkey, Greece, and Persia have been wasted to a shadow of their former self; ghouls and afrits

haunt the burial-places of the north African empires; and no invocation can break the death-slumber of Asia Minor. Acorns perish in the soil which once nourished the oaks of Bashan; outraged Nature refuses to be reconciled. With the glory of the Orbis Romanus the spring-time of our earth has departed, and what America mistakes for the prime of a new year is but the lingering mildness of an Indian summer.

The career whose swiftness is our national boast has led us upon a road which has never been far pursued with impunity; the rapidity of the destruction of our tree and game production is far more unparalleled than the growth of our cities; the misery of the Old World has not taught us to avoid its causes, and the history of its effects will not fail to repeat itself. On the frozen shores of Lake Winnipeg and the inaccessible heights of the central Rocky Mountains a few remnants of the old forests will probably survive; but the great East-American sylvania is already doomed; if we persist in our present course, our last timber-States, Maine, Michigan, and North Carolina, will be as bald as northern Italy in fifty years from now, and our last game will soon retreat to the festering swamps of southern Florida.

The temperate zone of America will soon be the treeless zone, with a single exception. In the sierras of southern Mexico large tracts of land still combine a generous climate with a rich arboreal vegetation. Mexico, like our own republic, has her backwoods States, but their security from the inroads of the destroyer is guaranteed by better safeguards than their remoteness from the great commercial centers. The ruggedness of the surrounding sierras, the supposed or real scarcity of precious metals, and the independent character of the aboriginal population, all conspire to make the *alturas* or mountain forests as unattractive to the imperious Spaniards as they are inviting to freedom-loving visitors from the North.

To my rambles and adventures in these *alturas*, to their scenic charms, their strange fauna and vegetable wonders, I have devoted this volume; but I have rarely touched upon the mineral and agricultural resources of a region which should remain consecrate to the Hamadryads and their worshipers. The cities of the intervening "civilized" districts, too, I have only mentioned as wayside stations for the benefit of non-pedestrian tourists. New Spain makes no exception from the general rule that the nations of Europe have transformed their American dependencies after the image of their mother-countries, and only he who leaves the cities far behind can forget that Mexico was colonized under the auspices of St. Jago and Ximenes.

This collection of "Summer-land Sketches" is, therefore, neither a record of a pilgrimage to the shrines and cathedrals of Spanish America, nor a bid for the patronage of Southwestern land-agencies, but rather a guide-book to one of the few remaining regions of earth that may give us an idea of the tree-land eastward in Eden which the Creator intended for the abode of mankind. In the terrace-lands of western Colima and Oaxaca, near the head-waters of the Rio Lerma and the mountain-lakes of Jalisco, and in the lonely highlands of Vera Paz, we may yet see forests that have never been desecrated by an axe, and free fellow-creatures which have not yet learned to flee from man as from a fiend.

An Elementary Treatise on Analytical Geometry, embracing Plane Geometry and an Introduction to Geometry of Three Dimensions. By Edward A. Bowser. New York: D. Van Nostrand. 1880. Pp. 287.

Professor Bowser has produced a very excellent text-book, and has successfully accomplished his object of presenting his subject in a clear and concise manner, suited to the ready comprehension of the class of students for which it is designed. The demonstrations have been selected with regard to their being of recognized excellence, from all available sources, and when a line of proof could be simplified it has been done.

The Minor Arts. By Charles G. Leland. London: Macmillan & Co. 1880. Pp. 148. Price 90 cents.

The regard in which decorative work of all kinds is at present held has given a commercial value to many of those minor arts which have been heretofore viewed only in the light of accomplishments, and pursued only as a pastime. A large field of remunerative and agreeable employment is thus opened up to numbers of persons who could in no other way use their time and abilities to such advantage. These arts are mostly simple, and can be learned sufficiently well to enable the student to do at least passable work with a fair amount of diligence and at an inconsiderable cost. With the object of presenting such practical instruction in the use of the materials and the kind of work that can be made from them as the novice needs, in a convenient and easily accessible form, Mr. Leland has prepared the present little manual. The volume opens with a consideration of leather-work, of which there are three kinds, that known as *cuir bouilli*, in which the leather is softened and then molded, stamped, or otherwise shaped; sewed leather, and sheet-leather ornaments, such as leaves, flowers, etc. Mr. Leland devotes his attention chiefly to the first kind, which he shows is capable of producing in

a very simple way many elegant articles. In the chapter on porcelain-painting, the character of the pigments, the mode of drawing on porcelain, and the kinds of glaze produced are briefly touched upon. Simple instructions are given in the chapter on wood-carving, as also in the one on molding in plaster and gelatine. Other chapters treat of designing and transferring patterns, stenciling, mosaic-work, repoussé-work, and silver-chasing, and some minor manufactures not in themselves of sufficient importance to be given a separate place. The volume closes with a collection of useful receipts of cements, etc.

The Textile Record of America. By James W. Nagle & John W. Ryckman. Published monthly at Philadelphia, $3 per year.

This is a handsomely printed thirty-six-page monthly journal devoted to the interests of those engaged in producing textile materials and in weaving them into fabrics. The first and second numbers, for September and October of this year, have varied tables of contents, and the journal promises to be very serviceable to the trade of which it is the exponent. It is under the editorial direction of Mr. Lorin Blodget, and is, like everything else published in Pennsylvania, thoroughly protectionist in creed. A department devoted to coloring-improvements, both in dyes and their use, is conducted by Dr. Alfred L. Kennedy.

Diseases of the Throat and Nose. By Morell Mackenzie, M. D. London: Vol. I. Philadelphia: Presley Blakiston. 1880. Pp. 570. Price, $4.

This is an American reprint of the valuable work of Dr. Mackenzie, of London, whose long experience and extensive acquaintance with diseases of this class eminently fit him to treat of them. The work is addressed to the profession, and is, as it professes to be, a systematic treatise upon the subject. The matter of this first volume is arranged under the three headings of "The Pharynx," "The Larynx," and "The Trachea." Under each the anatomy of the organ is first considered, next the instruments used in operating upon it, and the diseases to which it is subject, and the method of treatment. The complete work will be in two volumes, the second treating of the diseases of the œsophagus, nasal cavities, and neck. This volume is now in press, and will shortly appear.

Memoirs of the Science Department, University of Tokio, Japan. Vol. III, Part I. Report on the Meteorology of Tokio for the Year 1879. By T. C. Mendenhall. Published by the University. Government Printing-Office. 1880. Pp. 42.

This memoir comprises the meteorological observations made at the observatory of the University of Tokio during the year 1879. The results are tabulated, and numerous charts show graphically the variations in temperature, in barometrical readings, force of wind, etc. Professor Mendenhall does not consider that any general conclusions can be drawn from observations extending over such a brief period of time; but, as they are to be continued, the data will in time be collected from which such conclusions can be safely drawn. The observations of the barometer and thermometer were made three times a day, and those on the direction of the wind at more frequent intervals. They were made by Japanese under the direction of Professor Mendenhall, and every care has been taken to have them accurate. The volume is issued in excellent style, and is entirely of Japanese manufacture.

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L'Année Archéologique (the Archeological Year): Archeological Calendar, Centenaries, Review of the Year in France and Abroad. By Anthyme Saint-Paul. Year 1879. Paris: A. Quantin. 1880. Pp. 340.

Sugar Analysis: a Description of the Methods used in estimating the Constituents. By M. Benjamin, Ph. B. Illustrated. New York. 1880. Pp. 18.

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The Trenton Gravel and its Relation to the Antiquity of Man. By Henry Carvill Lewis. From the "Proceedings of the Academy of Sciences of Philadelphia." Pp. 16.

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The Unification of Science. By Alfred Arnold. St. Augustine, Fla. 1880. Pp. 15.

On Rotting Wood. By Professor William H. Brewer, of Yale College. Read before the American Public Health Association, November 19, 1879. Pp. 3.

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Tide Tables of the Pacific Coast of the United States. Pp. 63.—Tide Tables of the Atlantic Coast of the United States. Pp. 129. United States Coast and Geodetic Survey Office. Washington: Government Printing-Office. 25 cents each.

Quarterly Report of the Chief of the Bureau of Statistics, Treasury Department. Three Months ending June 30, 1880. Washington: Government Printing-Office. 1880. Pp. 92.

Medical Hints on the Production and Management of the Singing Voice. By Lennox Browne, F. R. C. S. Edin. New York: M. L. Holbrook & Co. Pp. 77. 25 cents.

The Devonian Insects of New Brunswick. By Samuel H. Scudder. Anniversary Memoirs of the Boston Society of Natural History. With Plate. Boston. 1880. Pp. 41.

A Text-Book of the Physiological Chemistry of the Animal Body. By Arthur Gamgee, M. D., F. R. S. With Illustrations. Vol. I. London: Macmillan & Co. 1880. Pp. 487. $4.50.

On Slight Ailments: their Nature and Treatment. By Lionel S. Beale, M. B., F. R. S. Philadelphia: Presley Blakiston. 1880. Pp. 353. $1.50.

A Manual of Classical Literature. By Charles Morris. Chicago: S. R. Griggs & Co. 1880. Pp. 418. $1.75.

The Ocean as a Health Resort. By William S. Wilson, L. R. C. P. Lond. Philadelphia: Presley Blakiston. 1880. Pp. 260. $2.50.

POPULAR MISCELLANY.

Lieutenant Schwatka's Arctic Journey.—The gap left in our knowledge of the ill-fated Arctic Expedition of Sir John Franklin, by the successive search-parties sent in quest of the explorers, has now been filled, as completely as it seems ever likely to be, by the remarkable achievement of Lieutenant Schwatka and his comrades, who have recently returned from their Arctic journey, after an absence of more than two years. Though the expedition was the poorest equipped of any of the similar ones which preceded it, it has accomplished more than any other, and that in the face of what would have seemed to less intrepid explorers insurmountable difficulties. The expedition of Sir John Franklin, consisting of the two ships Erebus and Terror, with a total party of one hundred and twenty-eight men, was sent out in the spring of 1845, and was never more seen. The mystery which enshrouded their fate was first unveiled by Dr. Rae, who, in 1853, found and brought to England a number of relics of the missing party, which are now in the British Museum. Dr. Rae's journey was made in the same general direction as that of Lieutenant Schwatka, but not over the same ground. Another expedition was sent out in 1858 under the command of Sir Leopold McClintock, who succeeded in obtaining the only written record that has been found. This showed that Franklin died on board ship in 1847, and the task of leading the way over the trackless Arctic fields, where the whole party perished miserably from cold and hunger, devolved upon Captain Crozier, the next in command. Franklin penetrated as far north as latitude 77°, going through Baffin Bay, Barrow Strait, and up Wellington Channel, but was forced to return southward, and in latitude 70° was frozen in by the ice toward the close of 1846. The vessels were abandoned in the spring of 1848, and the party, now consisting of one hundred and five men, betook themselves to the land in the hope of reaching some outpost of the Hudson Bay Company. They reached an island named King William Land, beyond which they never got. The subsequent expeditions of Dr. Kane and Captain Hall gleaned some further information, but there was still much to be learned of the way and place in which the party perished, and of what had become of the records which they must have had with them. It was to clear up these points that the Schwatka expedition undertook its perilous and fortunately successful journey, upon information regarding the existence of records which seemed reliable. This information was that one Captain Barry, of a whaler, while wintering in Repulse Bay, had been given a spoon by the Esquimaux, which had belonged to the Franklin party, and that this captain had subsequently overheard some natives talking, and learned that this spoon came from a cairn in King William Land where there

were others, as well as books and papers. When the expedition arrived at its destination at a northern point of Hudson Bay, this story was found to be without foundation. Lieutenant Schwatka, however, determined to make the trip to King William Land, in the hope of obtaining new information of value. The journey was in every way a formidable undertaking, having to be made on sledges, many hundred miles across a totally unknown country, which had to be depended upon for food. The party consisted of four white men and thirteen Esquimaux, provided with but one month's provisions, but also amply supplied with the best and most accurate American guns, to whose perfection, as it proved, they were indebted for being able to successfully accomplish the task. The party left their camp upon Hudson Bay, which they had named Camp Daly, on the 1st of April, 1879, and reached it again in March, after eleven months' absence, having traveled more than three thousand miles, and experienced a degree of cold that seems incredible. The lowest temperature was $-71°$, or $103°$ below the freezing-point, while the mean temperatures for the months of November and December, 1879, and January, 1880, were $-49°$, $-50°$ and $-53·2°$. In such temperatures as these any object sears the skin as a red-hot iron, the slightest wind burns the face, and meat, hot from a boiling pot, freezes before it can be eaten. The story of the wanderings of the Franklin explorers, as learned by this party from the natives, and as confirmed by their personal search, is terrible in the extreme. These men were but a few hundred miles from waters frequented by whalers, and yet they all perished, and perished so as to leave hardly any evidence of their journey. So far as it could be traced, it was by Lieutenant Schwatka's party, and the bones that were found at different points along the desolate shore of King William Land were buried. Only one skeleton could be identified—that of Lieutenant Irving, and this was brought away by them. It was known by means of a medal found near by, which the natives, in their desecration of his grave, had forgotten to take. It was learned from the natives that one of the ships was sunk at a point about five miles west of Grant Point, near the Adelaide Peninsula. As the Esquimaux did not know how to get in by the deck, they cut a hole in the side on a level with the ice, through which they carried off what provisions and other things they could find, and in the spring, when the ice broke up, the ship sank. Across this Adelaide Peninsula, at a point named Starvation Cove, evidences were found that it was here that the last remnant of the party perished, and with them the records, Lieutenant Schwatka believing that they are irrecoverably lost. All the relics found here by the natives, as well as at other points, were destroyed, having been given to the children to play with, and in time were broken up and lost. Besides the knowledge gained of the Franklin party, the searchers obtained geographical results of value, and found a considerable error in the Admiralty chart, in the mapping of Back's River, which they found to extend a good deal east of south, instead of west of it.

The Marshall-Islanders.—A work recently published by Franz Hemshein, a resident German merchant and consul, on the language of the Marshall Islands, affords some interesting facts concerning this little Polynesian group and its people. The islands are of coral, and are called atolls, having for their foundation a ring-shaped coral reef on which a land surface has been formed of varying length, but only a few hundred yards in breadth, and rising but a few feet above the water-line. Channels through these banks connect the inclosed lagoons, which are seldom more than thirty or thirty-five fathoms deep, with the outer water. The channels are entirely wanting or are too shallow for ships in some of the islands. The thin soil supports a scanty vegetation, which is limited to only a few of the species peculiar to the South-Sea regions; but many useful plants have been imported from other islands and do well. The fauna is likewise insignificant, but has been increased by importations from abroad, along with which the universal rat has been introduced. The inhabitants are a small, slightly built people, who age early; the women have rounder faces than the men, with thin, fleshless hands, and begin to fade before they reach maturity. Four ranks are recognized among them. The

lowest are the Armidwon, or Kajur, who own nothing; above them are the Leadagedag, to whom they must bring provision, and whom they must obey. Men of the latter class are permitted to own property. The third rank, called the Budag, is composed of the brothers and sons of the king. Over all is the Irod, or king, from whom the Leadagedag receive their commands. The Kajurs are allowed to have but one wife; men of the other classes may have more. The Kajur has the right to take the single wife from a man of lower condition than himself, but the men of the second rank are not permitted to speak with the wife of the king; and if the king goes abroad, leaving his wife at home, all the Leadagedag and the Budag, except the sons of the king, must leave the island. If a woman in the higher ranks is put away by her husband, as may happen if she is childless, she can not be taken in marriage by any one of a lower condition; but a man may marry a woman of a higher rank than his own and be raised to her rank. The food of the islanders is scanty. Young cocoanuts take the place of the drinking water, which is brackish. Cocoa-nuts, pandanus, and bread-fruit form the regular food. Arrowroot, brought from the northern islands, cooked with finely cut cocoa-nut, forms a favorite dish. A kind of conserve is made by roasting the pandanus-fruit over a bed of hot coals and covered with hot sand. In two days the fruit is taken out, sliced, dried in the sun, and pressed into rolls, which can be kept for two years. Another preparation, piru, is made from the bread-fruit. The fruit is cut up, steeped in salt water, and beaten; it is then put away in a shady place and covered with leaves; the soft mass is kneaded on the second day, laid away for a week, and kneaded again, when it is ready for use, and will keep good for five or six months. The principal disease from which the people suffer, and the most fatal one, is a catarrhal cold resembling the glanders in beasts. Europeans are also liable to take it, but they have it in a milder form, and do not die of it. A skin-disease called the gogo is generally prevalent, but is not commonly dangerous. This disease is not due to lack of personal cleanliness, for the natives are so much in the water as to make such a condition rare, and it prevails chiefly with the men, who are most in the water. The guild of the heathen priests consisted chiefly of diviners. God was supposed to appear to them and disclose the future to them. During the interview, which usually lasted for two or three days, they took no food. They never ate or drank out of dishes that had been used, and broke the cups after they had drunken from them. They were supposed to know about the wind and the weather, and the chances of success in enterprises, and were called into the sick and expected to foretell whether they would live or die. Remedies for disease were and are wholly unknown. Warm water, a few leaves, and especially rubbing, which is carefully attended to by the women with conjuring words, are the only medicaments. The friends of the sick man were formerly accustomed to come to him, bringing pandanus leaves, which they would fold together in patterns of equal size; if the last fold came out of the same length with the others, the omen was considered a good one for an impending recovery; if otherwise, the sick man was taken away to a distance, depending on the length of the last fold. These and many other customs have gone or are going out of use, and occur only exceptionally in places where one tenth of the population have been converted to Christianity. Fights are rare; wars are carried on chiefly by one party trying to destroy the cocoa palms or burn the houses of the other. They never come to a battle, but are conducted by siege, and generally end by the besieged party yielding. The worst damage ensues after the war, when, the trees being cut down and the land wasted, a famine of five or six months' duration is nearly certain. The principal occupation of the inhabitants is fishing. To catch the flying-fish a large torch is burned in a dark night upon a fast-sailing canoe. The fish fly toward the glimmer and either strike the sail and fall down or are caught by the skillful fisherman with a long-handled net. The yellow-tail fish swims in schools, and is caught with two canoes which, tied together, draw a cord after them on the top of the water, and drive the fish into shallow places, where they are caught with little trouble. It is a curious fact that the fish will occasionally leap over the cord, but will never swim away under it.

Mats and hats are artfully woven out of the bark of a shrub called the loa, and colored in handsome patterns of yellow, red, and black. The natives formerly made numerous voyages to the islands of the whole Marshall group, and had charts of them, which were drawn and copied on sticks and stones.

Improvements in Electro-Motors and Dynamo-Machines.—In a paper recently read before the British Association, Mr. T. Weisendanger takes exception to some of the received theories regarding electro-motors and dynamo-generators, and points out an improved mode of construction for both. In regard to the relations of these two classes of machines, it has generally been held that the most efficient generator is also the most efficient motor. This Mr. Weisendanger considers erroneous. Dynamo-generators are efficient only when their field-magnets are able to retain at all times a certain amount of residual magnetism. Their cores are, therefore, usually made of hard cast iron, or, if of soft iron, they are attached to masses of cast iron so that these form part of them. None of the efforts hitherto made to construct dynamo-machines with soft-iron cores have met with success, and, as electro-motors to give the best results should have such cores, machines can not be made that will give the maximum efficiency in both kinds of work. The fact that the attempts to make dynamo-machines with soft-iron cores have resulted in failure, he considers, proves that the current theory of their action, viz., that the electricity is generated by the inductive action and reaction between the field-magnets and the armature, is inadequate. Even wrought iron contains some residual magnetism, and in large masses, and after it has been subjected to strong magnetization, the amount is considerable. By the theory, the smallest amount of such magnetism would be sufficient to start the action of the machine. Experiment, however, shows that this is not the case. Mr. Weisendanger does not offer a new theory, but insists that the present one needs to be amended to correctly express the facts. Attention is also called to the idea underlying the work of some recent experimenters, that the power of an electro-motor can be indefinitely increased by augmenting that of the field-magnets. This is characterized as a mischievous theory whose outcome is perpetual motion. The author, on the contrary, holds that there is a definite relation between the power of the field-magnets and the armature, which has yet to be experimentally determined. Assuming the relation of these sets of magnets to be one of equality, he has constructed a motor, in which the cores of the field-magnets are light pieces of soft iron, that gives very satisfactory results. Further experiments to determine the exact ratio of the power of the field and armature, he believes, will result in a much more perfect machine. The most novel and perhaps important part of Mr. Weisendanger's paper is that relating to the proper method of revolving the armature before the poles of the field-magnets. The present practice is to make the cores of the field-magnets and those of the armature of such shape that the circles in whose circumference they lie are concentric. The defect of this arrangement is, that the armatures approach the magnets through the space in which the intensity of the field is at a minimum. After the armature reaches the magnet, the distance between the two remains constant while they are passing each other. Mr. Weisendanger holds that in generators the strongest currents will be induced, and in motors the greatest amount of power obtained when the armature not only revolves in the most highly concentrated field, but when its entire motion is either one of approach to or withdrawal from the field-magnets. He, therefore, proposes that the field-magnets be set at an angle to the circle described by the revolving armature. This latter then approaches the former continuously to the very instant of its leaving them. The greater the number of magnets the more powerful the action, as the armature is throughout its entire movement either approaching or receding from the field-magnets. Mr. Weisendanger is very hopeful of the future possibilities of electricity. Our present machines he believes to be but very imperfect appliances, which further research may so improve that the electric current will eventually perform all the services now rendered by combustion. He

looks not only to electricity to furnish light, and, through the medium of present unutilized natural resources, motive power, but heat as well. The exhaustion of fuel-supply will inevitably drive us to seek and find some other agency to do our work, and this, he thinks there is good reason to believe, will be found in electrical energy.

A New Smelting-Furnace.—The utilization of petroleum for fuel in the various metallurgical operations, in steam generating, and generally where coal is industrially used, has been a favorite project with inventors for a dozen years or more. The advantages of such a fuel are very great, and the reward to the successful inventor of an apparatus that would make its use practicable would be correspondingly large. Like gas, a liquid fuel is under perfect control, and is in a form allowing of perfect combustion if properly burned. The fuel is, moreover, very abundant, the production having been for some time past in considerable excess of the demand. In one district alone something like six thousand barrels are daily running to waste through lack of storage capacity, and one of the largest producers of oil is now obtaining from the wells about fifteen thousand barrels per day more than can be marketed. The oil companies, as well as inventors who have hoped to make a fortune by a successful furnace, have been unceasing in their efforts to turn this fuel to industrial uses, but so far the devices—and they have been many—have uniformly failed. A furnace is, however, now being developed which seems to promise, if not a complete solution, at least a partial solution of the problem. The furnace consists, in reality, in an immense blowpipe-flame, which is made to play upon the ore to be smelted, when used for metallurgical purposes, and to pass through boiler-tubes when used for steam generating. In the metallurgical apparatus there is first a fuel-furnace in which any ordinary fuel may be used, or oil if preferred. Against the upper portion of the flame from this furnace a blast of air is projected, similar to that from the mouth blowpipe against the flame of a spirit-lamp. Into this blast, at the point where it strikes the fuel-furnace flame, a stream of oil is introduced. The on-going blast and the heat of the flame vaporize the oil, which is then in a condition to be completely consumed. The result of this arrangement is the production of a column of flame, some thirty or forty feet long, of high temperature. This flame is projected horizontally through an iron cylindrical shell, lined with fire-brick with a facing of graphite, into which the ore to be reduced is fed from a hopper at the farther end. The shell is slowly rotated, so that the entering ore, tumbling about, is brought into intimate contact with the flame. It is also slightly inclined, that the material may slowly feed into the flame, and the melted material run down into the crucible at the lower end, where it is tapped and the slag run off in the usual way. The farther end of the revolving cylinder is let into a chamber, built of brick, stone, or clay, which is divided into compartments by walls or sheets of incombustible material kept constantly wet by running water. The hot gases, carrying vapors of the metals and other ingredients of the ore, are here gradually cooled down and condensed, the character of the condensation depending upon the materials present in the ore. The burned gases are withdrawn from the condensing chamber by means of an exhaust-fan, and discharged into the atmosphere. The air and oil are both under perfect control, so that a heat suitable for smelting or for vaporizing can be produced at will. Several furnaces are shortly to be put into operation for the reduction of ores of the precious metals, on which experiments have so far chiefly been made. The inventor, however, expects to be able to use it successfully in making iron and steel, as well as in burning lime. A modified form is also suitable to the burning of pottery and glass-making. In using it for generating steam, the boiler-flue is made large, the flame at no point coming in contact with the metal, thus avoiding the burning out of the boiler, the chief difficulty encountered by most of the other devices using oil-fuel for steam-making. The experiments with the furnace upon an industrial scale have been as yet too few and imperfect to thoroughly test its value, but they seem to warrant the opinion that the furnace has capabilities that promise very well for its future usefulness.

The Markings of Meteoric Stones.—M. Daubrée, the eminent French geologist, in his recently published work on "Synthetic Studies in Experimental Geology," describes some experiments that he has made for the purpose of ascertaining the cause of the peculiar appearance of the surface of meteoric stones. These bodies are covered with a blackish coating, which is sometimes dull and sometimes brilliant, and indicates unmistakably that they have suffered modifications in passing through the atmosphere. Their fracture presents a globular surface, similar to the structure of terrestrial rocks, showing that a strong cohesion has been produced at the moment of their formation. The outer surface is also covered with rounded depressions forming little capsules. M. Daubrée had remarked that when a cannon loaded with coarse-grained powder was fired off, some grains, which were only partly burned, would fall at the muzzle of the piece. The hollowed surface of these grains bore a striking resemblance to the forms seen on the meteorites. He then performed an experiment by taking a rectangular plate of steel, rolling it up in such a way that it should be fully enveloped by the gases from the powder, putting it in a closed steel chamber, with a quantity of powder, and firing off the powder by means of the electric spark. The duration of the deflagration was less than half a second. The gases acquired a tension of from one to two thousand atmospheres, and a temperature estimated at about 3,600°. The action, though of very short duration, gave surprising results. The surface of the plate was hollowed into irregular furrows, which demonstrated the force of the gaseous currents, and a powder of sulphuret of iron was found in the bottom of the vessel. A half a second, then, was all the time that was required to produce a partial fusion of the steel, a considerable blowing up by the gases, and such a chemical action as the formation of a sulphuret of iron. The experiment was repeated with dynamite and other explosives, with identical results. From them, M. Daubrée has deduced the following interpretation of the meteoric phenomena: the meteorites enter the terrestrial atmosphere with an enormous swiftness. The great pressure of air to which they are subjected explains the incandescence which takes place, and the superficial fusion of the mass. The part of a projectile of this kind which is at the moment in front rams the air and compresses it exceedingly, and causes it to be agitated by energetic gyratory movements. In whirling thus, under such pressure, the air tends to screw and hollow out whatever it rubs against, and this mechanical action is accompanied and reënforced by a chemical action due to the combustible nature of the meteoric rocks at these high temperatures. These rocks contain enough particles of iron in the native state, or as a sulphuret, to largely favor combustion and disaggregation. Under these circumstances, the hollows are produced, which appear on one side or on all sides of the projectile, accordingly as it has not or has a motion of rotation. M. Daubrée has given to these hollows the name of *piezoglyptes*.

Relation of Age and Marriage to Suicide.—It has been a mooted question whether the old or the young were more prone to suicide. Statistics published by Dr. Bertillon, in an article on marriage in the French "Encyclopædic Dictionary of the Medical Sciences," prove that the propensity increases with advancing age. They are reënforced by statistics recently published in Sweden, which lead to substantially the same conclusion. The proportion of the number of suicides of the more advanced ages to the whole number of persons of corresponding ages appears to be less in Sweden than in France, but aside from this the proportion increases regularly in both countries from the age of fifteen or twenty years to that of sixty years. After about sixty years the tendency in both countries appears to diminish. The proportion of suicides among women is less at all ages than among men, but increases with the advance of years as with the men. The statistical work of Signor Morrelli, recently published at Milan, lends additional support to these views. Dr. Bertillon has also collected facts bearing on the effect of marriage upon the tendency to suicide, from which he has deduced the principles: 1. That widowers and widows commit suicide more frequently than married persons; and, 2, that the presence of children in the family makes the probability of suicide more re-

mote. The salutary influence of children is equally marked with married and widowed persons, with men and women. The Swedish statistics may be brought in again to enlarge our knowledge on this point by showing the combined influence of marriage and age. According to these tables, the difference in the liability of married men and celibates, while they are still young, is very slight. The tendency to suicide then increases slowly among married men as they grow older, and at its maximum (at about sixty to sixty-five years of age) is two and one half times (26 in 100,000) what it was at the adult age (10 to 11 per 100,000). After the sixty-fifth year it diminishes. With unmarried persons, on the other hand, the tendency increases with almost a geometrical progression. At twenty-five years of age it is more than double (26 per 100,000) what it is with married persons of the same age (11 per 100,000), and at seventy years is eleven times as great (230 against 21 per 100,000); and after this period it goes on increasing as fast as ever, while the proportion for married persons is diminishing. The phenomena with women are analogous, but less marked. It is found, by comparing the statistics of the two classes, that the general increase in the tendency to commit suicide with advancing age can be almost wholly accounted for by this progression of suicides among the unmarried. The difference in the liability of the two classes may be partly explained by setting off the regularity of habit which married life and particularly the care for children induce with the irregularities to which the unmarried surrender themselves, of which the most damaging is drunkenness. Signor Morrelli says that drunkenness causes thirty-one per cent. of the suicides in Denmark, and that a similar rule prevails everywhere.

Artificial Lights.—The great point of difference between natural and artificial lights, says Dr. Javal, the French occulist, is the excessive feebleness of the latter. A lamp or a gas-jet makes an insignificant impression in daylight. The light of a million candles burning in a room would be vastly inferior in intensity to that of the direct rays of the sun. The pupils of our eyes are considerably larger in the most brilliantly lighted room than they are in daylight. We seek the brightest places of resort at night, and use the strongest lights we can afford in our homes, employing every means to make them stronger. Persons with imperfect sight are fatigued in working with artificial lights because the enlargement of their pupils gives full play to faults which are mitigated under the contraction of the aperture which a strong light induces. The spectra of all artificial lights, except the magnesium and electrical lights, are different from the spectrum of sunlight in that they are dark on the most refracted side, that of the blue, violet, and chemical rays. It may be that this quality compensates in part for the greater dilatation of the pupil which these lights require by reducing the amount of chromatic refraction which would otherwise take place. It does not appear, however, that any workmen prefer such lights to sunlight. It has been suggested that the presence of these rays in the electric light might cause it to be injurious. If that should prove to be the case, any evil effect might be remedied by shading the pencils with yellow-tinted globes. No complaint has been made, however, of bad effects arising from the proper use of this light. Those who have studied it most attentively have felt no inconvenience except when they looked intently at it without guarding their eyes. It is not intended to be used thus; and, if we judged by this criterion, the sun would be the worst of all lights. When the electric light was first introduced into the freight depots in Paris, the workmen complained of being dazzled by it. After some weeks, it was taken away, and gas was put in its place, when a general outcry went up against the darkness.

A Solar Machine.—The idea of applying the heat of the sun directly as a motive force has been entertained as within the limits of possibility for some time. A Frenchman, M. Mouchot, devised a machine, about two years ago, for concentrating the rays of the sun so that they could be made to perform some slight offices. M. Abel Pifre, an engineer associated with M. Mouchot, has carried on some experiments in Algeria with an adaptation of his machine which have had a promising degree of success. His apparatus

was small, yet it was sufficient, by the aid of the sun of last October, to produce steam enough to keep a sewing-machine in continuous motion, cook food, and boil water. M. Mouchot's machine consists of a reflector in the form of a truncated cone, which concentrates the rays of the sun upon a kettle placed in the axis of the cone, with a bell-glass to cover the kettle and protect it from external cooling. Such machines are not likely to be of much practical use in temperate climates, where the sun is comparatively weak and often clouded; but in hot, arid regions, like the deserts of Africa, they may possibly yet be employed advantageously.

Consumption and Climates.—Dr John C. Thorowgood, of the London Hospital for Diseases of the Chest, in a paper on "Atmospheric and Climatic Influence in the Causation and Cure of Pulmonary Disease," distinguishes between two classes of phthisis, or consumption of the lungs, in which the operation of this influence is very different. The first kind, the consumption which originates in catarrh, cold, or some inflammatory attack, prevails in raw, cold climates, and is relieved by going to a mild climate. The second kind, true tubercular consumption, comes on insidiously, often from no cold caught, from no privation of food, but simply from some inherent, perhaps hereditary vice in the system, and is a febrile disease, having much the character of rapid blood-poisoning. It is not peculiar to cold climates, and is not relieved by sending the patient to a mild one. The worst that can be done in cases of either form of disease is, to confine the patient closely to one room, and let him breathe over and over again the same atmosphere, while the cough is kept checked by opiates. In this way, says Dr. Thorowgood, consumption may be cultivated and developed from the first class into the more serious form of the second class, so that it becomes a fearfully destructive malady. "In the cases of young children who are kept very close in heated rooms, and who are said to be always taking cold, we often see most obstinate cough and catarrh, due to the throwing off from the air-passages of a weak, poorly-nourished epithelium, which in time may choke the air-cells, and so lead to pulmonary consumption. The cure consists in laying aside paregoric and squills while we feed the epithelium with pure air. Appetite soon returns, and the cough speedily takes its flight." The tendency of confinement in a close atmosphere to cause blood-spitting and consumption has been demonstrated by the statistics obtained by Dr. Gray when engaged in investigating the effects of certain trades on the health of those employed. The author of the paper under notice has seen excellent results, in removing lingering inflammation after an acute attack on the chest, follow a sojourn at Torquay, Ventnor, and similar mild, warm health-resorts; but when the disorder has passed from the inflammatory stage to one that involves the general nutrition, and is marked by softening and breaking down of lung-tissue, with night-sweats and copious purulent expectoration, he has never seen any good come of a residence in a mild, sedative climate. On the other hand, he tells of several cases in which persons suffering from the latter form have been relieved, and have even recovered after being sent to a cold, bracing climate, or to a high mountain elevation. The author's views were confirmed, in the discussion by the medical society before which it was read, by several speakers. The president of the society mentioned three cases of complete cure of decided pulmonary consumption of non-catarrhal origin by change of air—in one case to Moscow, in two others to Canada. Another speaker mentioned cases of catarrhal phthisis that had been cured by sojourn at mild resorts.

Effect of Physical Training on Respiration.—M. Marey has made an investigation of the modifications which are induced in the respiratory movements by the fact of muscular action. It is well known that muscular action provokes, in those who are not accustomed to it, panting, that is, a respiration stronger and more frequent than the normal respiration. This is in consequence of the greater rapidity of the current of blood which in its abundance demands, in order to pass through the lungs, more frequent or more ample respirations. The habit of muscular exercise, running, for example, has the effect of gradually adapting the respiratory function to the most rapid cir-

culation which can pass the lungs. The respiratory type acquired by the gymnast consists in an enormous increase in the expansion of the chest and a notable retardation of the thoracic movements. M. Marey and Dr. Hillairet selected five recruits and registered the rate of respiration of each of them when at rest, and again after they had run a course of six hundred metres at the gymnastic pace. By following the changes of respiration of these gymnasts from month to month, a series of curves was obtained, and the following results were furnished: At first, respiration was very perceptibly modified by the running; but toward the end of the experiments, that is, after four or five months of the exercises, it was almost impossible to distinguish any change in the respiration of the men who had run; and this, notwithstanding their gait had become a little more rapid, and they ran over the six hundred metres in three minutes and fifty seconds. The figures show that the modification of the respiratory movements is permanent—that is, that it is maintained when the man is at rest. The number of respirations is reduced, in the mean, from twenty to about twelve in a minute, and their amplitude is more than quadrupled. We may conclude, then, that these soldiers, after having experienced the effects of gymnastic training, breathe about twice as much air as before they were subjected to the discipline.

Expectant Attention in Animals.—A remarkable instance of sagacity in animals is described in an article on "Mental Physiology" in a late number of the "Edinburgh Review," in the case of a dog that belonged to Professor Huggins. This dog, Kepler, had the faculty of answering correctly with his barkings arithmetical questions, including such problems as giving the square root of nine or sixteen, or the result of adding seven to eight, dividing the sum by three, and multiplying the quotient by two. No power of calculation was implied in this exercise, or operation of the understanding, however it may have seemed. The case was simply one of what is called by physiologists expectant attention. A clew to the process is given by the statement in the story that, until the solution was arrived at, Kepler never moved his eye from his master's face, but the instant the last bark was given he transferred his attention to the cake which was always held before him as a reward for a successful performance. Professor Huggins, the writer continues, was perfectly unconscious of suggesting the proper answer to the dog, but it is beyond all question that he did so. The wonderful fact is, that Kepler had acquired the habit of reading in his master's eye or countenance some indication that was not known to Professor Huggins himself. Professor Huggins was engaged in working out mentally the various stages of his arithmetical processes as he propounded the numbers to Kepler, and, being aware, therefore, of what the answer should be, expected the dog to cease barking when the number was reached; and that expectation suggested to his own brain the unconscious signal which was caught by the quick eye of the dog. In an analogous manner, a person swinging a button by a thread near the rim of a glass will unwittingly cause it to strike the hour, if he knows the hour, through the unconscious control of his brain over the movements of his finger.

Change as a Mental Restorative.—Dr. Joseph Mortimer-Granville, discussing in the "Lancet" the subject of "Change as a Mental Restorative," shows that great discrimination is needed in prescribing this remedy. Some patients there are, such as those who have become wearied with a purposeless life or one of idle dissipation, who have become worn out with change, and to whom a prescription of it for its own sake, without consideration of the circumstances, would only impose an additional infliction. They are most difficult cases to deal with, and demand especial study. The change which a person of this kind requires is "one that will stir a deeper spring of energy than has yet supplied him with motive-force, by compelling his recognition of the responsibilities of life. It is idle to hope that he can be roused to action by the discovery of a new pleasure. . . . The energies of such a character are more likely to be called out by pain and necessity than by pleasure and satisfaction." Some men of pleasure have been delivered from the extreme of *ennui*, which they had reached, by the loss of for-

tune bringing pressing need for exertion; but this remedy is beyond the reach of a physician. He might aim, however, to supply an incentive to action by searching for "some inherited seed of ambition or enterprise which has never yet germinated," and may sometimes find it by learning the story of the father's or grandfather's life. A case which came under Dr. Granville's care, and which furnished him with the basis for his remarks on this subject, was cured by the awakening of a strong passion for the breeding of stock, which he had inherited from his grandfather, but which had not been aroused in his nature till he was thrown into circumstances which excited him to emulate the success of a neighbor. A similar case, where no such awakening of energy occurred, ended in suicide.

The Mirage on Swiss Lakes.—Professor Charles Dufour communicated to the French Association, at its last meeting, a paper on the mirages of the Swiss lakes, which are often seen between the month of August and the spring, especially in the morning, when the water is warmer than the air. When Monge published his explanation of the mirage, he supposed that the strata of air near the ground were warmer and rarer than the strata above, but he could not prove it experimentally. Professor Dufour has proved it by taking the temperature at different heights above Lake Leman, while the sun was still hidden by the mountains. The mirage frequently produces curious illusions. When a boat is near the point where the ray of light is a tangent to the surface of the water, the mirage of the sky is thrown below the boat, and the latter seems to sail in the air. Seen from Villeneuve, the steamboat plying between Montreux and Vevay seems to be sailing among the vineyards which cover the hills along the shore. When the air, on the other hand, is warmer than the water, as is the case generally in the spring and summer on fine afternoons, the concave side of the refracted ray of light is turned toward the water, and objects are brought into sight which are really hidden by the roundness of the earth. Sometimes the temperature of the different strata of the air varies irregularly. Then the rays of light undergo abnormal refractions which are not always the same for the upper and lower parts of objects. Consequently, the objects are sometimes diminished, sometimes magnified in an extraordinary fashion. Small houses thus distorted are made to look like palaces; their white color is changed into gray by the diffusion of the light, and they are thereby given an air of greater grandeur. Many persons fail to take notice of these mirages because they regard them as reflections from the water; but it is really possible for one with his eye near the water to see the reflection from it of a distant object on nearly the same level. When an image of such an object is seen, it is most probably a mirage.

Variations in the Fixed Points of Thermometers.—M. Crafts, in the course of his investigation of the causes of the variations of the fixed points of thermometers, has discovered that glass heated for a long time in the blowpipe-flame shrinks in consequence of an internal change. It is not shown that pressure plays any part in the phenomenon. The particles of the glass which have been separated by the heating do not return to the normal position immediately on cooling, but appear to be in a disturbed condition for some time afterward. The action of heat at a given temperature, say of 670°, by giving a greater mobility to the particles, favors their return to the normal position; but the glass, in cooling from this temperature, retains a part of the expansion which it has undergone. By heating it anew to an inferior temperature, say 570°, we may produce a new diminution of volume, and thus successively, by a very slow process of cooling, bring about the greatest approximation to the normal state, and consequently the greatest stability. The law discovered by M. Pernet for temperatures between the freezing and boiling points of water, according to which the depressions of the freezing-point are proportional to the squares of the temperatures, is not true at high temperatures. A thermometer, for example, which gives a depression of half a degree after a long exposure at 212°, ought, by this law, to give at 670° a depression of 6.8°. The depressions actually observed are much less considerable.

The Deep Valley of the Caribbean Sea.—Commander J. R. Bartlett, of the Coast-Survey steamer Blake, has ascertained some interesting facts in regard to the depths of the western part of the Caribbean Sea. The data he has obtained make it probable that a large portion of the supply for the Gulf Stream passes through the "Windward Passage" between Cuba and San Domingo, and that the current extends in it to the depth of 800 fathoms. The temperature, of $39\frac{1}{2}°$, which was indicated at all depths below 700 fathoms in the Gulf of Mexico and the western Caribbean, was not obtained here. Elsewhere, in these seas, the temperature decreased from the surface to $39\frac{1}{2}°$ at 700 fathoms or less, and remained constant at that temperature for all lower depths. At greater depths than 600 or 700 fathoms the bottom was always found to be a calcareous ooze composed of pteropod shells with small particles of coral. An immense, deep valley was found to extend from between Cuba and Jamaica to the westward, south of the Cayman Islands, well up into the Bay of Honduras. It has a length of 430 miles, and a general breadth of 105 miles, with a depth nowhere of less than 2,000 fathoms, except at two or three points where the summits of submarine mountains rise to near the surface. Within 20 miles of Grand Cayman it attains an extreme depth of 3,428 fathoms; this island is therefore, to the bottom of the valley, as a mountain 20,000 feet high, and Blue Mountain, in Jamaica, rises 29,000 feet above the bottom, or as high as the highest of the Himalayas is above the level of the sea. The deepest part of the valley has been named the "Bartlett Deep."

NOTES.

Mr. Rogers Field, in a recent lecture on house-drainage at the Parkes Museum of Hygiene, condemned all forms of water-traps as a means of excluding sewer-gas from dwellings, on the ground that they allow the gases to pass through them by the water absorbing it on one side and giving it off on the other. In his opinion, the only sure way to keep these gases out of the house is by thorough ventilation and disconnection. Efficient ventilation means a continuous current of fresh air through the drains and pipes, but even then perfect security can only be obtained by cutting off direct communication between the sewer and the house-drains.

The last annual report of the New Haven Board of Health contains a valuable letter addressed to the Common Council of that city, by the President of the Board, Professor William H. Brewer, of the Sheffield Scientific School, setting forth in a forcible way the financial advantages of a thorough system of sanitary administration in towns and villages. This letter should be in the hands of all the village trustees in the land, many of whom may be reached by money considerations when mere questions of life and death would scarcely arrest attention.

In its crusade against the London shop-keepers for obliging their saleswomen to stand continually during business hours, the "Lancet" is disposed to lay a part of the blame on the patrons of these establishments. It thinks if there were any real sympathy, on the part of the public, for the young persons who are made to suffer by the system of standing, it would long ago have been brought to a summary close. We sometimes hear of women having a special faculty for nursing the sick: they should show in this matter that they have the humanity to avoid the creation of needless disease.

Mr. Nilson has prepared a quantity of the oxide of the new metal ytterbium, or ytterbine, and finds the atomic weight of the metal to be 17·301. Ytterbine appears in the state of an infusible white powder of a density of 9·175, insoluble in water, but easily dissolved in acids, even when diluted, at a boiling heat; but, when cold, they attack it with difficulty, even if concentrated. The solutions are colorless, and show no absorption rays in the spectrum. The earth and its salts do not communicate any color to flames; but the chloride gives a very bright spectrum with the electric spark.

A new remedy for neuralgia has been introduced into England from the Feejee islands. It is called *tonga*, and is brought in the shape of fragments of woody fiber, bark, and leaves, broken up into pieces so small as to make it hard to identify them botanically, mixed and done up into balls of about the size of an orange. To prepare it, the ball is soaked in cold water for about ten minutes, when the infusion is drawn off and a claret-glass of it is taken three times a day. The ball is then dried and hung up, and can be used over and over again for a year. The principal constituent of the remedy appears to be the stem of a species of *Raphidophora*.

M. Lortet, who has been studying the fauna of the Lake of Tiberias, reports that

its surface is 212 metres (689 feet) below the level of the Mediterranean, and that its greatest depth, which is at the northern extremity opposite the upper mouth of the Jordan, is 250 metres (812 feet). On both shores of the lake are terraces covered with rounded pebbles, rising to a height which indicates that the level of the lake was once the same as that of the Mediterranean. He believes that the waters of the lake were formerly very salt, more so than sea-water, but not so excessively salt as the waters of the Dead Sea, and that they have been freshened since the level of the lake was lowered by volcanic convulsions, by the flow of the Jordan, till they have become drinkable.

Professor Schneltzler, assuming that the color of flowers is due to the combination of different chemical elements in their tissues, has shown by experiment that when an alcoholic extract of the color is made it is enough to add to it an acid or alkaline substance to cause it to exhibit any of the colors which plants present. Flowers of the peony, for example, give a violet liquid in alcohol; if salt of sorrel is added to this liquid, it will turn a pure red; soda produces, according to the quantity that is added, violet, blue, or green.

Those in pursuit of the marvelous may learn a grain of caution from the following, taken from an article on "Living Toads in Stone" by Mr. Thomas G. Denny, in a recent number of "Science Gossip": "Most of us have heard of 'Flint Jack,' but I do not think many readers of this journal have met with any manufacturers of fossil toads; but I knew many years ago a working naturalist living in Leeds who used to prepare for sale toads, stated to have been found in beds of coal, by baking them perfectly black and hard in an oven, and then taking square pieces of coal and, after splitting them carefully, he would cut a hollow in each portion to receive the 'ancient reptile.'"

Mr. Frederick Ransome has succeeded in producing a good hydraulic cement from the slag of blast-furnaces. His process, which is applicable to almost any quality of slag, has the advantage over previous methods of making cement, that while in them the materials, lime, silica, and alumina, had to be brought together and carefully combined, in blast-furnace slag the combination has already been completely effected before the slag has left the furnaces, and generally with the proportions of silica and alumina that are required. By mixing the slag with an additional quantity of lime and calcining the mass, a strong and reliable cement of an agreeable color is produced.

It has been affirmed, in proof of the theory that fat is formed from albumen, that the albumen of the cheese in the cellars of Roquefort is changed to fat by the action of a fungus found there. The assertion is disproved by experiments made by Herr Sieber on the cheese in these cellars, which show that the most marked change that cheese undergoes in ripening is the loss of water, and that the proportion of fat remains unaltered if only the dry substance be considered. A decomposition of the albumen also takes place, the caseine passing into a series of decomposition-products which are similar to products of putrefaction in the first stage of putrefactive fermentation, but the analyses show no transformation of albumen into fat.

Efforts to reduce monkeys to discipline have not very often been successful. A native of the province of Bengal has, however, trained several of them to work the cords by which the *punka*, or ventilating fan of India, is moved. They perform their task to perfection, and, thanks to their activity, keep the *punkas* in continuous motion, maintaining a constant, agreeable movement of air all through the room.

Dr. Henry Barnes records a case of an extremely severe attack of gout brought on by sleeping in a newly painted room. Three years before, the patient, an old man, had suffered a slight attack of the disease (the first of his life), but soon recovered, and, up to the time of this exposure, had been quite free from gouty symptoms. The introduction of lead into the system is given as the cause of the attack.

A company with large capital has been formed in Paris to work up an invention for coating thread with silk. The invention embraces, according to the "Bulletin des Soies," a chemical process for covering linen or other vegetable threads with amesh of silken matter in a manner similar to that in which metallic objects are plated with gold or silver. The process is dependent on the fact, which has long been known, that silk is soluble in several strong acid preparations.

The French Chamber of Deputies has voted a credit of fifty thousand francs to M. Pasteur to enable him to extend his researches upon the contagious diseases of animals. The labors of M. Pasteur during the last four years have already led to the discovery of the causes of carbonaceous affections, and the knowledge thus gained has been employed to prevent them in many cases. His present investigations are in relation to the character of virulent maladies in general.

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THE DEVELOPMENT OF POLITICAL INSTITUTIONS.

By HERBERT SPENCER.

III.—POLITICAL INTEGRATION.

POLITICAL integration is in some cases furthered, and in other cases hindered, by conditions, external and internal. There are the characters of the environment, and there are the characters of the men composing the society. We will glance at them in this order.

How political integration is prevented by an inclemency of climate, or an infertility of soil, which keeps down population, has been already shown.* To the instances before named may be added that of the Seminoles, of whom Schoolcraft says, "Being so thinly scattered over a barren desert, they seldom assemble to take black drink, or deliberate on public matters"; and, again, that of certain Snake Indians, of whom he says, "The paucity of game in this region is, I have little doubt, the cause of the almost entire absence of social organization." We saw, too, that great uniformity of surface, of mineral products, of flora, of fauna, are impediments; and that on the special characters of the flora and fauna, as containing species favorable or unfavorable to human welfare, in part depends the individual prosperity required for social growth. It was also pointed out that structure of the habitat, as facilitating or impeding communication, and as rendering escape easy or hard, has much to do with the size of the social aggregate formed. To the illustrations before given, showing that mountain-haunting peoples, and peoples living in deserts and marshes, are difficult to consolidate, while peoples penned in by barriers are consolidated with facility,† I may here add two significant ones not yet noticed. One occurs in the Polynesian Islands—Tahiti, Hawaii, Ton-

* "Principles of Sociology," §§ 14–21.

† Ibid., § 17.

ga, Samoa, and the rest—where, restrained within limits by surrounding seas, the inhabitants have become united more or less closely into aggregates of considerable sizes. The other is furnished by ancient Peru, where, before the time of the Incas, semi-civilized communities had been formed in valleys separated from each other "on the coast, by hot and almost impassable deserts, and in the interior by lofty mountains, or cold and trackless *punas*." And to the implied inability of these peoples to escape governmental coercion, thus indicated by Squier as a factor in their civilization, is ascribed, by the ancient Spanish writer Cieza, the difference between them and the neighboring Indians of Popayan, who could retreat, "whenever attacked, to other fertile regions." How, conversely, within the area occupied, the massing of men together is furthered by ease of internal communication, is sufficiently manifest. The importance of it is implied by the remark of Grant concerning equatorial Africa, that "no jurisdiction extends over a district which can not be crossed in three or four days." And such facts, implying that political integration may increase as the means of going from place to place become better, remind us how, from Roman times downward, the formation of roads has made larger social aggregates possible.

Evidence that a certain type of *physique* is requisite has been elsewhere given. * We saw that the races which have proved capable of evolving large societies have been races previously subject, for long periods, to conditions fostering vigor of constitution. I will here add only that the constitutional energy needed for continuous labor, without which there can not be civilized life and the massing of men that accompanies it, is an energy not to be quickly acquired under any conditions or through any discipline, but to be acquired only by inherited modifications slowly accumulated. Good evidence that in lower types of men there is a physical incapacity for continuous labor, is supplied by the results of the Jesuit government over the Paraguay Indians. These Indians were reduced to industrial habits, and to an orderly life which was thought by many writers admirable ; but there eventually resulted the fatal evil that they became infertile. Not improbably, the infertility habitually observed in savage races that have been led into civilized habits, is consequent on taxing the *physique* to a degree greater than it is constituted to bear.

Certain moral traits which favor, and others which hinder, the union of men into large groups, were pointed out when treating of "The Primitive Man—Emotional." † Here I will reillustrate such of these as concern the fitness or unfitness of the type for subordination. "The Abors, as they themselves say, are like tigers, two can not dwell in one den," writes Mr. Dalton ; and "their houses are scattered singly, or in groups of two and three." Conversely, some of the African races not only yield when coerced, but admire one who coerces them ;

* "Principles of Sociology," § 16. † Ibid., Part I, chapter vi.

instance the Damaras, who, as Galton says, "court slavery" and "follow a master as spaniels would." The like is alleged of other South Africans. One of them said to a gentleman known to me: "You're a pretty fellow to be a master; I've been with you two years and you've never beaten me once." Obviously the dispositions thus strongly contrasted are dispositions on which the impossibility or possibility of political integration largely depends. There must be added, as also influential, the presence or the absence of the nomadic instinct. Varieties of men, in whom wandering habits have been unchecked during countless generations of hunting life and pastoral life, show us that, even when forced into agricultural life, their tendency to move about greatly hinders aggregation. It is thus among the hill-tribes of India. "The Kookies are naturally a migratory race, never occupying the same place for more than two or, at the utmost, three years"; and the like holds of the Mishmees, who "never name their villages"—the existence of them being too transitory. In some races this migratory instinct survives and shows its effects, even after the formation of populous towns. Writing of the Bachassins in 1812, Burchell says that Litakun, containing 15,000 inhabitants, had been twice removed during a period of ten years. Clearly, people so little attached to the localities they were born in are not so easily united into large societies as people who love their early homes.

Concerning the intellectual traits which aid or impede the cohesion of men into masses, I may supplement what was said when delineating "The Primitive Man—Intellectual," * by two corollaries of much significance. Social life, being coöperative life, presupposes not only an emotional nature fitted for coöperation, but also such intelligence as perceives the benefits of coöperation, and can so regulate actions as to effect it. The unreflectiveness, the deficient consciousness of causation, and the utter lack of constructive imagination, shown by the uncivilized, hinder coöperation to a degree difficult to believe until proof is seen. Even the semi-civilized exhibit in quite simple matters an absence of concert which is astonishing.† Implying, as this inaptitude

* "Principles of Sociology," Part I, chapter vii.

† The behavior of Arab boatmen on the Nile displays this inability to coöperate in simple matters in a striking way. When jointly hauling at a rope, and beginning, as they do, to chant, the inference one draws is that they pull in time with their words. On observing, however, it turns out that their efforts are not combined at given intervals, but are put forth without any unity of rhythm. Similarly, when using their poles to push the dahabeiah off a sand-bank, the succession of grunts they severally make is so rapid that it is manifestly impossible for them to give those effectual combined pushes which imply appreciable intervals of preparation. Still more striking is the want of concert shown by the hundred or more Nubians and Arabs employed to drag the vessel up the rapids. There are shoutings, gesticulations, divided actions, utter confusion; so that only by accident does it at length happen that a sufficient number of efforts are put forth at the same moment. As was said to me by our Arab dragoman, a traveled man, "Ten Englishmen or Frenchmen would do the thing at once."

does, that coöperation can at first be effective only where there is obedience to peremptory command, it follows that there must be not only an emotional nature which produces subordination, but also an intellectual nature which produces faith in a commander. That credulity which leads to awe of the capable man, as a possessor of supernatural power, and which afterward, causing dread of his ghost, prompts fulfillment of his remembered injunctions—that credulity which initiates the religious control of a deified chief, reënforcing the control of his divine descendant—is a credulity which can not be dispensed with during early stages of integration. Skepticism is fatal while the character, moral and intellectual, is such as to necessitate compulsory coöperation.

Political integration, then, hindered in many regions by environing conditions, has, in many races of mankind, been prevented from advancing far by unfitnesses of nature—physical, moral, and intellectual.

Besides certain fitnesses of nature in the united individuals, social union requires a considerable likeness of kind in their natures. At the outset the likeness of kind is insured by greater or less kinship in blood. Evidence of this meets us everywhere among the uncivilized. Of the Bushmen, Lichtenstein says: "Families alone form associations in single small hordes; sexual feelings, the instinctive love to children, or the customary attachment among relations, are the only ties that keep them in any sort of union." Again, "The Rock Veddahs are divided into small clans or families associated for relationship, who agree in partitioning the forest among themselves for hunting-grounds," etc. And this rise of the society out of the family, seen in these least organized groups, reappears in the considerably organized groups of more advanced savages. Instance the New-Zealanders, of whom we read that "eighteen historical nations occupy the country, each being subdivided into many tribes, originally families, as the prefix Ngati, signifying offspring (equivalent to O or Mac), obviously indicates." This connection between blood-relationship and social union is well shown by Humboldt's remarks concerning South American Indians. "Savages," he says, "know only their own family, and a tribe appears to them but a more numerous assemblage of relations." When Indians who inhabit the missions see those of the forest, who are unknown to them, they say: "They are, no doubt, my relations; I understand them when they speak to me." But these very savages detest all who are not of their family or their tribe; "they know the duties of family ties and of relationship, but not those of humanity."

When treating of the domestic relations, reasons were given for concluding that social stability increases as kinships become more definite and extended; since development of kinships, while insuring the likeness of nature which furthers coöperation, involves the strengthen-

ing and multiplication of those family bonds which check disruption. Where promiscuity is prevalent, or where marriages are temporary, the known relationships are relatively few and not close ; and there is little more social cohesion than results from belonging to the same type of man. Polyandry, especially of the higher kind, produces relationships of some definiteness, which admit of being traced further ; so serving better to tie the social group together. And a greater advance in the nearness and the number of family connections results from polygyny. But, as was shown, it is from monogamy that there arise family connections which are at once the most definite and the most widespreading in their ramifications ; and out of monogamic families are developed the largest and most coherent societies. In two allied yet distinguishable ways does monogamy favor social solidarity.

Unlike the children of the polyandrous family, who are something less than half brothers and sisters, and unlike the children of the polygamous family, most of whom are only half brothers and sisters, the children of the monogamous family are, in the great majority of cases, all of the same blood on both sides. Being thus themselves more closely related, it follows that their clusters of children are more closely related ; and where, as happens in early stages, these clusters of children when grown up continue to form a community, and labor together, they are united alike by their kinships and by their industrial interests. Though with the growth of a family group into a *gens* which spreads, the industrial interests divide, yet these kinships prevent the divisions from becoming as marked as they would otherwise become. And, similarly, when the *gens*, in course of time, develops into the tribe. Nor is this all. If local circumstances bring together several such tribes, which are still allied in blood, though more remotely, it results that when, seated side by side, they are gradually fused, partly by interspersion and partly by intermarriage, the compound society formed, united by numerous and complicated links of kinship as well as by political interests, is more strongly bound together than it would otherwise be. Dominant ancient societies illustrate this truth. Says Grote : "All that we hear of the most ancient Athenian laws is based upon the gentile and phratric divisions, which are treated throughout as extensions of the family." Similarly, according to Mommsen, on the "Roman household was based the Roman state, both as respected its constituent elements and its form. The community of the Roman people arose out of the junction (in whatever way brought about) of such ancient clanships as the Romilii, Voltinii, Fabii, etc." And Sir Henry Maine has shown in detail the ways in which the simple family passes into the house community, and eventually the village community. Though, in presence of the evidence furnished by races having irregular sexual relations, we can not allege that sameness of blood is the primary reason for political coöperation—though in numerous tribes which have not risen into the pastoral state,

there is combination for offense and defense among those whose names are recognized marks of different bloods—yet where there has been established descent through males, and especially where monogamy prevails, sameness of blood becomes largely, if not mainly, influential in determining political coöperation. And this truth, under one of its aspects, is the truth above enunciated, that combined action, requiring a certain likeness of nature among those who carry it on, is, in early stages, most successful among those who, being descendants of the same ancestors, have the greatest likeness.

An all-important though less direct effect of blood-relationship, and especially that more definite blood-relationship which arises from monogamic marriage, has to be added. I mean community of religion—a likeness of ideas and sentiments embodied in the worship of a comman deity. Beginning, as this does, with the propitiation of the deceased founder of the family, and shared in, as it is, by the multiplying groups of descendants, as the family spreads, it becomes a further means of holding together the compound cluster gradually formed, and checking the antagonisms that arise between the component clusters: so favoring integration. The influence of the bond supplied by a common cult everywhere meets us in ancient history. Each of the cities in primitive Egypt was a center for the worship of a special divinity; and no one who, unbiased by foregone conclusions, observes the extraordinary development of ancestor-worship, under all its forms, in Egypt, can doubt the origin of this divinity. Of the Greeks we read that "each family had its own sacred rites and funereal commemoration of ancestors, celebrated by the master of the house, to which none but members of the family were admissible: the extinction of a family, carrying with it the suspension of these religious rites, was held by the Greeks to be a misfortune, not merely from the loss of the citizens composing it, but also because the family gods and the manes of deceased citizens were thus deprived of their honors and might visit the country with displeasure. The larger associations, called Gens, Phratry, Tribe, were formed by an extension of the same principle—of the family considered as a religious brotherhood, worshiping some common god or hero with an appropriate surname, and recognizing him as their joint ancestor."

A like bond was generated in a like manner in the Roman community. Each curia, which was the homologue of the phratry, had a head, "whose chief function was to preside over the sacrifices." And, on a larger scale, the same thing held with the entire society. The primitive Roman king was a priest of the deities common to all; "he held intercourse with the gods of the community, whom he consulted and whom he appeased." The beginnings of this religious bond, here exhibited in a developed form, are still traceable in India. Sir Henry Maine says, "The joint family of the Hindoos is that assemblage of persons who would have joined in the sacrifices at the funeral of

some common ancestor if he had died in their lifetime." So that political integration, while furthered by that likeness of nature which identity of descent involves, is again furthered by that likeness of religion simultaneously arising from this identity of descent.

Thus is it, too, at a later stage, with that less pronounced likeness of nature characterizing men of the same race who have multiplied and spread in such ways as to form adjacent small societies. Coöperation among them continues to be furthered, though less effectually, by the community of their natures, by the community of their traditions, ideas, and sentiments, as well as by their community of language. Among men of diverse types, coöperation is necessarily hindered not only by that absence of mutual comprehension caused by ignorance of one another's words, but also by unlikenesses in their ways of thinking and feeling. It needs but to remember how often, even among those who speak the same language, quarrels arise from misinterpretations of things said, to see what fertile sources of confusion and antagonism must be the partial or complete differences of speech which habitually accompany differences of race. Similarly, those who are widely unlike in their emotional natures, or in their intellectual natures, perplex one another by unexpected conduct—a fact on which travelers habitually remark. Hence a further obstacle to combined action. Diversities of custom, too, become causes of dissension. Where a food eaten by one people is regarded by another with disgust, where an animal held sacred by the one is by the other treated with contempt, where a salute which the one expects is never made by the other, there must be continually generated alienations which hinder joint efforts. Other things equal, facility of coöperation will be proportionate to the amount of fellow-feeling; the fellow-feeling is prevented by whatever prevents men from behaving in the same ways under the same conditions. The working together of the original and derived factors above enumerated is well exhibited in the following passage from Grote: "The Hellens were all of common blood and parentage—were all descendants of the common patriarch Hellen. In treating of the historical Greeks, we have to accept this as a datum: it represents the sentiment under the influence of which they moved and acted. It is placed by Herodotus in the front rank, as the chief of those four ties which bound together the Hellenic aggregate: 1. Fellowship of blood; 2. Fellowship of language; 3. Fixed domiciles of gods, and sacrifices common to all; 4. Like manners and dispositions."

Influential as we thus find to be the likeness of nature which is insured by common descent, the implication is that, in the absence of considerable likeness, the larger political aggregates formed are unstable, and can be maintained only by a coercion which, some time or other, is sure to fail. Though other causes have conspired, yet this has doubtless been a part cause of the dissolution of great empires in past ages. At the present time the decay of the Turkish Empire is

largely if not chiefly ascribable to it. Our own Indian Empire, too, held together by force in a state of artificial equilibrium, threatens some day to illustrate, by its fall, the incohesion arising from lack of congruity in its components.

One of the laws of evolution at large is, that integration results when like units are subject to the same force or to like forces ("First Principles," § 169); and, from the first stages of political integration up to the last, we find this law illustrated. Joint exposure to uniform external actions and joint reactions against them have from the beginning been the leading causes of union among members of societies.

Already there has been indirectly implied the truth that coherence is first given to small hordes of primitive men during combined opposition to enemies. Subject to the same danger, and uniting to meet this danger, they become, in the course of their coöperation against it, more bound together. In the first stages, this relation of cause and effect is clearly seen in the fact that such union as arises during a war disappears when the war is over: there is dispersion and loss of all such slight political subordination as was beginning to show itself. But it is by the integration of simple groups into compound groups, in the course of common resistance to foes and attacks upon them, that this process is best exemplified. The cases before given may be reënforced by others. Of the Karens, Mason says: "Each village, being an independent community, had always an old feud to settle with nearly every other village among their own people. But the common danger from more powerful enemies, or having common injuries to requite, often led to several villages uniting together for defense or attack." According to Kolben, "smaller nations of Hottentots, which may be near some powerful nation, frequently enter into an alliance, offensive and defensive, against the stronger nation." Among the New Caledonians, in Tanna, "six, or eight, or more of their villages unite, and form what may be called a district, or county, and all league together for mutual protection. . . . In war, two or more of these districts unite." In Samoa, "villages, in numbers of eight or ten, unite by common consent, and form a district or state for mutual protection"; and, in time of war, these districts themselves sometimes unite in twos and threes. The like has happened with historic peoples. It was during the wars of the Israelites, in David's time, that they passed from the state of separate tribes into the state of a consolidated ruling nation. The scattered Greek communities, previously aggregated into minor confederacies by minor wars, were prompted to the Panhellenic congress and to the subsequent coöperation, when the invasion of Xerxes was impending; and, of the Spartan and Athenian confederacies afterward formed, that of Athens acquired the hegemony, and finally the empire, during continued operations

against the Persians. So, too, was it with the Teutonic races. The German tribes, originally without federal bond, formed occasional alliances for war. Between the first and fifth centuries these tribes gradually massed into great groups for resistance against or attack upon Rome. During the subsequent century the prolonged military confederations of peoples "of the same blood" had become states. And afterward these became aggregated into still larger states. And, to take a comparatively modern instance, it was during the wars between France and England that each passed from that condition, in which its component feudal groups were in considerable degrees independent, to the condition of a consolidated nation. As further showing how integration of smaller societies into larger ones is thus initiated, it may be added that at first the unions exist only for military purposes: each component society retains for a long time its independent internal administration, and it is only when joint action in war has become habitual that the cohesion is made permanent by a common political organization.

This compounding of smaller communities into larger by military coöperation is insured by the disappearance of such smaller communities as do not coöperate. Barth remarks that "the Fúlbe [Fulahs] are continually advancing, as they have not to do with one strong enemy, but with a number of small tribes without any bond of union." Of the Damaras, Galton says: "If one werft is plundered, the adjacent ones rarely rise to defend it, and thus the Namaquas have destroyed or enslaved piecemeal about one half of the whole Damara population." Similarly, according to Ondegardo, with the Inca conquests in Peru: "There was no general opposition to their advance, for each province merely defended its land without aid from any other." This process, so obvious and familiar, I name because it has a meaning which needs emphasizing. For we here see that, in the struggle for existence among societies, the survival of the fittest is the survival of those in which the power of military coöperation is the greatest; and military coöperation is that primary kind of coöperation which prepares the way for other kinds of coöperation. So that this formation of larger societies by the union of smaller ones in war, and this destruction or absorption of the smaller ununited societies by the united larger ones, is an inevitable process through which the varieties of men most adapted for social life supplant the less adapted varieties.

Respecting the integration thus effected, it remains only to remark that it necessarily follows this course—necessarily begins with the formation of simple groups and advances by the compounding and the recompounding of these. Impulsive in conduct and with feeble powers of coöperation, savages cohere so slightly that only small bodies of them can maintain their integrity. Not until such small bodies have severally had their members bound to one another by some slight political organization does it become possible to unite them into larger

bodies; since the cohesion of these implies greater fitness for concerted action, and more developed organization for achieving it. And, similarly, these composite clusters must be to some extent consolidated before the composition can be carried a stage further. Passing over the multitudinous illustrations occurring among the uncivilized, it will suffice if I refer to those given before,* and reënforce them by some which historic peoples have supplied. There is the fact that in primitive Egypt the numerous small societies (which eventually became the "nomes") first united into the two aggregates, Upper Egypt and Lower Egypt, which were afterward joined into one; and the fact that, in ancient Greece, villages became united to adjacent towns before the towns became united into states, while this change preceded the change which united the states with one another; and the fact that, in the old English period, small principalities were massed into the divisions constituting the Heptarchy before these passed into something like a united whole. It is a principle in physics that, since the force with which a body resists strains increases only as the squares of its dimensions, while the strains which its own weight subject it to increase as the cubes of its dimensions, its power of maintaining its integrity becomes relatively less as its mass becomes greater. Something analogous may be said of societies. Small aggregates only can hold together while the cohesion is feeble, and successively larger aggregates become possible only as the greater strains implied are met by that greater cohesion which results from an adapted human nature, and a resulting development of social organization.

As social integration advances, the increasing aggregates exercise increasing restraints over their units—a truth which is the obverse of the one just set forth, that the maintenance of its integrity by a larger aggregate implies greater cohesion. The coercive forces by which aggregates keep their units together are at first very slight, and, becoming extreme at a certain stage of social evolution, afterward relax—or, rather, change their forms.

At the outset the individual savage gravitates to one group or other, prompted by sundry motives, but mainly by the desire for protection. Concerning the Patagonians, we read that no one can live apart: "If any of them attempted to do it, they would undoubtedly be killed, or carried away as slaves, as soon as they were discovered." In North America, among the Chinooks, "on the coast a custom prevails which authorizes the seizure and enslavement, unless ransomed by his friends, of every Indian met with at a distance from his tribe, although they may not be at war with each other." At first, however, though it is necessary to join some group, it is not necessary to continue in the same group. In early stages migrations from group to group are common. When much oppressed by their chief, Calmucks

* "Principles of Sociology," § 226.

and Mongols desert him and go over to other chiefs. Of the Abipones, Dobrizhoffer says: "Without leave asked on their part, or displeasure evinced on his, they remove with their families whithersoever it suits them, and join some other cacique; and, when tired of the second, return with impunity to the horde of the first." Similarly, in South Africa, "the frequent instances which occur [among the Balonda] of people changing from one part of the country to another show that the great chiefs possess only a limited power." And how, through this process, some tribes grow while others dwindle, we are shown by McCulloch's remark respecting the Kukis, that "a village, having around it plenty of land suited for cultivation and a popular chief, is sure soon, by accessions from less favored ones, to become large."

With the need which the individual has for protection is joined the desire of the tribe to strengthen itself; and the practice of adoption, hence resulting, constitutes another mode of integration. Where, as among tribes of North American Indians, "adoption or the torture were the alternative chances of a captive" (adoption being the fate of one admired for his bravery), we see reillustrated the tendency which each society has to grow at the expense of other societies. That desire for many actual children whereby the family may be strengthened, which Hebrew traditions show us, readily passes into the desire for factitious children—here made one with the brotherhood by exchange of blood, and there by mock birth. As was implied in another place,* it is probable that the practice of adoption into families so prevalent in Rome arose during those early times when the wandering patriarchal group constituted the tribe, and when the desire of the tribe to strengthen itself was dominant. And, indeed, on remembering that, long after larger societies were formed by the compounding of patriarchal groups, there continued to be feuds between the component families and clans, we may see that there had never ceased to operate, on such families and clans, the primitive motive for strengthening themselves by increasing their numbers.

It may be added that kindred motives produced kindred results within more modern societies, during times when their component parts were so imperfectly integrated that there remained antagonisms among them. Thus we have the fact that in mediæval England, while local rule was incompletely subordinated to general rule, every free man had to attach himself to a lord, a burgh, or a guild: being otherwise "a friendless man," and in a danger like that which the savage is in when not belonging to a tribe. And then, on the other hand, in the law that, "if a bondsman continued a year and a day within a free burgh or municipality, no lord could reclaim him," we may recognize an effect of the desire on the part of industrial groups to strengthen themselves against the feudal groups around—an effect analogous to the adoption, here into the savage tribe and there into the family

* "Principles of Sociology," § 319.

as it existed in the ancient societies. Naturally, as a whole nation becomes more completely integrated, these local integrations become weaker, and finally disappear; though they long leave their traces, as among ourselves even still in the law of settlement, and as, up to so late a period as 1824, in the laws affecting the freedom of traveling of artisans.

These last illustrations introduce us to the truth that, while at first there are little cohesion and great mobility of the units forming a group, advance in integration is habitually accompanied not only by a decreasing ability to go from group to group, but also by a decreasing ability to go from place to place with the group: the members of the society become less free to move about within the society as well as less free to leave it. Of course, the transition from the nomadic to the settled state partially implies this; since each person becomes in a considerable degree tied by his material interests. Slavery, too, effects in another way this binding of individuals to locally-placed members of the society, and therefore to particular parts to it; and, where serfdom exists, the same thing is shown with a difference. But in societies that have become highly integrated, not simply those in bondage, but others also, are tied to their localities. Of the ancient Mexicans, Zurita says: "The Indians never changed their village nor even their quarter. This custom was observed as a law." In ancient Peru, "it was not lawful for any one to remove from one province, or village, to another"; and "any who traveled without just cause were punished as vagabonds." Elsewhere, along with that development of the militant type accompanying aggregation, there have been imposed restraints on movement under other forms. In ancient Egypt there existed a system of registration, and all citizens had periodically to report themseves to local officers. "Every Japanese is registered, and, whenever he removes his residence, the Nanushi, or head-man of the temple, gives a certificate." And then, in despotically governed European countries, we have more or less rigorous passport-systems, hindering the movements of citizens from place to place, and in some cases preventing them from leaving the country.

In these, as in other respects, however, the restraints which the social aggregate exercises over its units decrease as the industrial type begins greatly to qualify the militant type; partly because the societies characterized by industrialism are amply populous, and have superfluous members to fill the places of those who leave them, and partly because, in the absence of the oppressions accompanying a militant *régime*, a sufficient cohesion results from pecuniary interests, family bonds, and love of country.

Thus, saying nothing for the present of that political evolution manifested by increase of structure, and restricting ourselves to that political evolution manifested by increase of mass, here dis-

tinguished as political integration, we find that this has the following traits :

While the aggregates are small, the incorporation of materials for growth is carried on at one another's expense in feeble ways—by taking one another's game, by robbing one another of women, and, occasionally, by adopting one another's men. As larger aggregates are formed, incorporations proceed in more wholesale ways: first, by enslaving the separate members of conquered tribes, and presently by the bodily annexation of such tribes. And, as compound aggregates pass into doubly and trebly compound ones, there arise increasing desires to absorb adjacent smaller societies, and so to form still larger aggregates.

Conditions of several kinds further or hinder social growth and consolidation. The habitat may be fitted or unfitted for supporting a large population; or it may, by great or small facilities for intercourse within its area, favor or impede coöperation; or it may, by presence or absence of natural barriers, make easy or difficult the keeping together of the individuals under that coercion which is at first needful. And, as the antecedents of the race determine, the individuals may have in greater or less degrees the physical, the emotional, and the intellectual natures fitting them for combined action.

While the extent to which social integration can in each case be carried depends in part on these conditions, it also depends in part upon the degree of likeness among the units. At first, while the nature is so little molded to social life that cohesion is small, aggregation is largely dependent on ties of blood, implying great degrees of likeness. Groups in which such ties, and the resulting congruity, are most marked, and which, having family traditions in common, a common male ancestor, and a joint worship of him, are in these further ways made alike in ideas and sentiments, are groups in which the greatest social cohesion and power of coöperation arise. For a long time the clans and tribes descending from such primitive patriarchal groups have their political concert facilitated by this bond of relationship and the likeness it involves. Only after adaptation to social life has made considerable progress does harmonious coöperation among those who are not of the same stock become practicable; and even then their unlikenesses of nature must fall within moderate limits. Where the unlikenesses of nature are great, the society, held together only by force, tends to disintegrate when the force fails.

Likeness in the units forming a social group being one condition of their integration, a further condition is their joint reaction against external action; coöperation in war is the active cause of social integration. The temporary unions of savages for offense and defense show us the initiatory step. When many tribes unite against a common enemy, long continuance of their combined action makes them

coherent under some common control. And so it is subsequently with still larger aggregates.

Progress in social integration is both a cause and a consequence of a decreasing separableness among the units. Primitive wandering hordes exercise no such restraints over their members as prevent them individually from leaving one horde and joining another at will. Where tribes are more developed, desertion of one and admission into another are less easy—the assemblages are not so loose in composition. And, throughout those long stages during which societies are being enlarged and consolidated by militancy, the mobility of the units is more and more restrained. Only with that substitution of voluntary coöperation for compulsory coöperation which characterizes developing industrialism do these restraints disappear: enforced union being in such societies adequately replaced by spontaneous union.

A remaining truth to be named is that political integration, as it advances, tends to obliterate the original divisions among the united parts. In the first place, there is the slow disappearance of those non-topographical divisions arising from relationship, and resulting in separate gentes and tribes, gentile and tribal divisions, which are for a long time maintained after larger societies have been formed: gradual intermingling destroys them. In the second place, the smaller local societies united into a larger one, which at first retain their separate organizations, lose them by long coöperation: a common organization begins to ramify through them, and their individualities become indistinct. And, in the third place, there simultaneously results a more or less decided obliteration of their topographical bounds, and a replacing of these by the new administrative bound of the common organization. Hence naturally results the converse truth that, in the course of social dissolution, the great groups separate first, and afterward, if dissolution continues, these separate into their component smaller groups. Instance the ancient empires successively formed in the East, the united kingdoms of which severally resumed their autonomies when the coercion keeping them together ceased. Instance, again, the Carlovingian empire, which, first parting into its large divisions, became in course of time further disintegrated by subdivision of these. And where, as in this last case, the process of dissolution goes very far, there is a return to something like the primitive condition, under which small predatory societies are engaged in continuous warfare with like small societies around them.

PHYSICAL EDUCATION.

By FELIX L. OSWALD, M. D.

DIET.

"Blessed are the pure, for they can follow their inclinations with impunity."

UNNATURAL food is the principal cause of human degeneration. It is the oldest vice. If we reflect upon the number of ruinous dietetic abuses, and their immemorial tyranny over the larger part of the human race, we are tempted to eschew all symbolical interpretations of the paradise legend, and to ascribe the fall of mankind literally and exclusively to the eating of forbidden food. From century to century the same cause has multiplied the sum of our earthly ills. Substances which Nature never intended for the food of man have come to form a principal part of our diet; caustic spices torture our digestive organs; we ransack every clime for noxious weeds and intoxicating fluids; from twenty to thirty-five per cent. of our breadstuffs are yearly wasted on the distillation of a life-consuming fire; vegetable poisons, inorganic poisons, and all kinds of indigestible compounds enslave our appetites, and among the Caucasian nations of the present age an unexampled concurrence of causes has made a passive submission to that slavery the habitual condition.

Dietetic abuses, alone, would amply account for all our "ailments and pains, in form, variety, and degree beyond description"; the vitality of the human race would, indeed, have long succumbed to their combined influence, if their effects were not counteracted by the reconstructive tendency of Nature. Every birth is an hygienic regeneration. The constitutional defects which degenerate parents transmit to their offspring are modified by the inalienable bequest of an elder world—the redeeming instincts which our All-mother grants to every new child of earth. Individuals may deprave these instincts till their functions are entirely usurped by the cravings of a vicious appetency, but this perversion is never hereditary; Nature has ordained that all her children should begin the pilgrimage of life from beyond the point where the roads of misery and happiness diverge. As the golden age, the happy childhood of the human race returns in the morning of every life, the normal type of our primogenitor asserts itself athwart the morbid influences of all intermediate generations; the regenesis of every new birth brings mankind back from vice to innocence, from mysticism to realism, from ghost-land to earth. For a time those better instincts thwart the influence of miseducation as persistently as confirmed vices afterward thwart the success of reformatory measures; but, if the work of correct physical culture were begun in time, our innate propensities

themselves would conspire to further its purposes and bar the boundary between virtue and vice which conscience often guards in vain. The temptations that beset the path of the adult convert do not exist for the wards of Nature. To the palate of a normal child, alcohol is as unattractive as corrosive sublimate; the enforced inactivity of our limbs, which afterward becomes dyspeptic indolence, is as irksome to a healthy boy as to a wild animal, and a young Indian would prefer the open air of the stormiest winter night to the hot miasma of our tenement-houses. Few smokers can forget the effects of the diffident first attempt—the revolt of the system against the incipience of a virulent habit. The same with other abuses of our domestic and social life. If we would preserve the purity of our physical conscience, we might refer all hygienic problems to an unerring oracle of Nature.

The appearance of the eye-teeth (cuspids) and lesser molars marks the end of the second year as the period when healthy children may be gradually accustomed to semi-fluid vegetable substances. Till then, milk should form their only sustenance. As a substitute for the nourishment of their mother's breast, cow's-milk, mixed with a little water and sugar, is far superior to all patent paps, Liebig's compounds, and baby-soups, which often induce a malignant attack of the dysenteric complaint known as "bowel-fever" or "weaning-brash," unless palliated by still more condemnable astringents and soothing-sirups. In France the professional wet-nurses of the Pays de Vaud are generally engaged as *nourrices de deux ans;* but mothers whose employment does not interfere with their inclination in this respect may safely nurse their children for a much longer period. The wives of the sturdy Argyll peasants rarely wean a bairn before its claim is disputed by the next youngster; and the stoutest urchin of five years I ever saw was the son of a poor Servian widow, who still took him to her breast like a baby. Animals suckle their young till they are able to digest the unmodified solid food of the species; and the best method with weanlings, therefore, is perhaps that of the Ionian-Islanders, whose toddling infants, as Dr. Bodenstedt noticed, partake of the simple repast of their parents—unleavened maize-cakes and dried figs—and are often permitted to exercise their teeth on a fresh-plucked ear of sugar-corn. But, in countries where the repast of parents is anything but simple, the best food for young children is a porridge of milk and boiled rice or oatmeal, with a little sugar, perhaps, or a few spoonfuls of apple-butter in summer-time. Of such simple dishes a child may be permitted to eat its fill, but they should be served at regular intervals and never be taken hot. Heating our food is one of the many devices for disguising its natural taste, and sipping hot and cold drinks, turn about, is far more injurious to the teeth than the *penchant* for sweetmeats which children share with savages and monkeys. Beginning with five light meals a day, the number may be gradually reduced to three, after which a system of fixed hours should be strictly observed, till the symptoms of

appetite manifest a corresponding periodicity, thus saving mothers the trouble of providing baby-titbits at all possible and impossible hours of the day. Healthy children of five take readily to an exclusively vegetable diet, which is often preferable to city milk and always to flesh-food. Xenophon, in his miscellaneous "Anabasis," mentions a tribe of Bithynian coast-dwellers whose children were prodigies of chubbedness, "as thick as they were long," and remarks that said chubs were fed on—boiled chestnuts. Baked apples, pulse, macaroni, whipped eggs, bread-pudding seasoned with sugar and a drop or two of lemon-flavor, and such fruits as mellow pears, raspberries, and strawberries, can be readily assimilated by all but the weakliest nursery cadets.

But toward the end of the seventh year the advent of a second and sturdier set of teeth suggests the propriety of exercising the jaws on more solid substances. A child of seven should graduate to a seat at the family table; or rather the family table should offer nothing that a child of seven can not digest. It does, though, as a rule, and parents who buy their meals ready made, or who have resigned themselves to evils from which they would save their children, should still regulate their bill of fare, both in quality and in quantity, by the rules of hygiene rather than by those of etiquette or convenience, till the age of confirmed habits puts them beyond the danger of temptation.

Before entering upon those points, I must premise a few words on the main question, What is the natural food of man? As an abstract truth, the maxim * of the physiologist Haller is absolutely unimpeachable: "Our proper nutriment should consist of vegetable and semi-animal substances which can be eaten with relish before their natural taste has been disguised by artificial preparation." For even the most approved modes of grinding, bolting, leavening, cooking, spicing, heating, and freezing our food are, strictly speaking, abuses of our digestive organs. It is a fallacy to suppose that hot spices aid the process of digestion: they irritate the stomach and cause it to discharge the ingesta as rapidly as possible, as it would hasten to rid itself of tartarized antimony or any other poison; but this very precipitation of the gastric functions prevents the formation of healthy chyle. There is an important difference between rapid and thorough digestion. In a similar way, a high temperature of our food facilitates deglutition, but, by dispensing with insalivation and the proper use of our teeth, we make the stomach perform the work of our jaws and salivary glands; in other words, we make our food less digestible. By bolting our flour and extracting the nutritive principle of various liquids, we fall into the opposite error: we try to assist our digestive organs by performing mechanically a part of their proper and legitimate functions. The health of the human system can not be maintained on concentrated nutriment; even the air we inhale contains azotic

* Endorsed (indirectly) in the writings of Drs. Alcott, Claude Bernard, Schlemmer, Hall, and Dio Lewis, and directly by Schrodt and Jules Virey.

gases which must be separated from the life-sustaining principle by the action of our respiratory organs—not by any inorganic process. We can not breathe pure oxygen. For analogous reasons bran-flour makes better bread than bolted flour; meat and saccharine fruits are healthier than meat-extracts and pure glucose. In short, artificial extracts and compounds are, on the whole, less wholesome than the palatable products of Nature. In the case of bran-flour and certain fruits with a large percentage of wholly innutritious matter, chemistry fails to account for this fact, but biology suggests the mediate cause: the normal type of our physical constitution dates from a period when the digestive organs of our (frugivorous) ancestors adapted themselves to such food—a period compared with whose duration the age of grist-mills and made dishes is but of yesterday.

We can not doubt that the highest degree of health could only be attained by strict conformity to Haller's rule, i. e., by subsisting exclusively on the pure and unchanged products of Nature. In the tropics such a mode of life would not imply anything like asceticism: a meal of milk and three or four kinds of sweet nuts, fresh dates, bananas, and grapes would not clash with the still higher rule, that eating, like every other natural function, should be a pleasure and not a penance. Heat destroys the delicate flavor of many fruits and makes others less digestible by coagulating their albumen. But in the frigid latitudes, where we have to dry and garner many vegetable products in order to survive the unproductive season, the process of cooking our food has advantages which fully outweigh such objections. Few men with post-diluvian teeth would agree with Dr. Schlemmer that hard grain is preferable to bread. No Bostoner would renounce his favorite dish for a nose-bag full of dry beans. Dried prunes, too, are improved by cooking—in taste, at least, and perhaps in digestibility. Besides, we should not forget that the natural taste of such substances, before they became over-dry, *was* agreeable, or at least not repulsive to our palates. It appears that on week-days the children of Israel indulged their poor in the practice of snatching free luncheons from a convenient corn-field (Matthew xii, 1), and the Imam of Muscat still feeds his soldiers on crude wheat and dhourra-corn, a sort of millet, which many French soldiers learned to eat raw, as their Mameluke captors declined to cook it for them. Even the legumes—peas, beans, and lentils—pass through a period when they are soft and full of sweet milk-juice, though in their sun-dried over-ripeness they become as tough as wood. In the scale of wholesomeness the place next to Haller's man-food *par excellence* should therefore be assigned to vegetable substances whose pleasant taste has been *restored* by the process of cooking. With this addition, even an invalid, dieting for his health, need not complain of lack of variety, for the number of nutritious vegetables that can be successfully cultivated as far north as Hamburg and Boston is almost infinite if we include the plants of the corresponding Asiatic latitudes

and those that could be acclimatized in the course of five or six seasons. With five kinds of cereals, three legumina, eight species of esculent roots, ten or twelve nutritive herbs, thirty to forty varieties of tree-fruits, besides berries and nuts, a vegetarian might emulate the Duc de Polignac, who refused to eat the same dish more than once per season. Honey is the pure, unchanged, and unalloyed saccharine juice of flowers and resinous exudations, and therefore strictly a vegetable substance, though Carl Bock and Bichat describe it as semi-animal food, because "derived from animals," i. e., hived by bees. They might as well include flour under the same category because horses carry grist to the mill. Like sugar, vanilla, and the manna-sirup of Arabia Felix, we might class it with the non-stimulating condiments, which, used in moderate quantities, impart an agreeable flavor to many farinaceous preparations without impairing their digestibility.

Of all semi-animal substances, sweet fresh milk is the most wholesome, in itself an almost perfect aliment, welcome to all mammals and nearly all vertebrate animals. Monkeys, cats, deer, squirrels, otters, and ant-bears, creatures that differ so widely in their *special* diet, will rarely refuse a dish of this universal food. I have seen snakes and iguanas drink it with avidity. On the other hand, I have noticed that all animals but pigs and starved dogs eschew sour milk ; it is, properly speaking, fermented milk, to the taste of a normal man probably as repulsive as tainted meat or sour gruel. This fermentation affects the fatty particles less than the watery and caseine ; and butter and cream (though less digestible than fresh milk) are, therefore, far healthier than sour whey and cheese. Cheese in some of its forms is quite as unwholesome as rotten flesh ; putrid curd would be the right name for Limburger and fromage de Brix. Vegetarians of the Lankester school object to milk and butter on account of the spurious stuff that is often foisted upon the market under those names, but mild-tasted aliments can hardly be adulterated with very injurious substances ; a little tallow, oleomargarine, or even lard, mixed with butter, and as such again mixed with a tenfold quantity of farinaceous food, can only affect the most delicate constitutions to any appreciable degree, and certainly not more than the small percentage of alum we often eat with our daily bread. Comparatively speaking, such things are the veriest trifles, and we can not afford to fight gnats while we are beset by a swarm of vampires. We have dietetic exquisites who would shudder at the idea of raising their biscuits with brewer's yeast instead of bicarbonate of soda, but do not hesitate to sandwich that same bread with strong cheese and pork-sausage ; or pity the wretch whose poverty consents to North Carolina apple-jack, while they sip a *petite verre* of aromatic schiedam. That kind of purism often reminds me of the fastidiousness of Heinrich Heine's Mandarin convict, who insists on being thrashed with a perfumed bamboo, "but would have been shocked at a less fragrant hiding."

All kinds of fat ("non-nitrogenous" aliments), including butter and cream, are more digestible in winter than in summer time. Cold air is a peptic stimulant, and neutralizes the calorific effect of a non-nitrogenous diet, while fresh tree-fruits and berries counteract an excess of atmospheric heat, and thus, by an admirable provision of Nature, the seasons themselves furnish us the food most adapted to the preservation of the right medium temperature of the system. Preserved fruits (raisins, dried figs and apples, etc.) lose much of their acidity, and thus become less refreshing, but not less nutritive, at the very time when the latter property is the more important one. Cow's-milk, on the other hand, grows richer in winter-time, and this self-adaptation of their food to the varying demands of the seasons enables the inhabitants of such countries as Italy and Mexico to subsist all the year round on an almost uniform diet. But in a climate of such thermal extremes as ours it would be the best plan to vary our regimen with the weather, and, above all, to adopt a special summer diet, since the consequences of our present culinary abuses are far less baneful in January than in July. Even in mid-winter our compounds of steaming and greasy viands with hot spices severely strain the tolerance of a youthful stomach; but, when the dog-star adds its fervid influence, the demand for refrigerating food becomes so imperative that no forensic eloquence would persuade me to convict a city lad for hooking watermelons. Where fruit is cheap the *paterfamilias* should keep a storeroom full of summer apples, and leave the key in the door—it will obviate costiveness and midnight excursions. From May to September fresh fruit ought to form the staple of our diet, and the noonday meal at least should consist of cold dishes, cold apple-pudding with sweet milk and whipped eggs, or strawberries with bread, cream, and sugar. The Romans of the republican age broke their fast with a biscuit and a fig or two, and took their principal meal in the cool of the evening. In their application of the word, a frugal diet meant quite literally a diet of tree-fruits, and that our primogenitor was a frugivorous creature is the one point in which the Darwinian genesis agrees with the Mosaic version.

Dr. Alcott holds that a man might live and thrive on an exclusive diet of well-selected fruits, and I agree with him if he includes olives and oily nuts, for no assumption in dietetics is more gratuitous than the idea that a frequent use of flesh-food is indispensable to the preservation of human health. Meat is certainly not our *natural* food. The structure of our teeth, our digestive apparatus, and our hands, proves *a priori* that the physical organization of man is that of a frugivorous animal. So do our instincts. Accustom a child to a diet of milk, bread, and meat; never let him see a fruit, nor mention the existence of such a thing; then take him to an orchard, and see how quick his instinct will tell him what apples are good for. Turn him loose among a herd of lambs and kids: he will play with them as a fellow-vege-

tarian. In a slaughter-house the sight of gory carcasses and puddles of blood will excite him with a *horror naturalis.* The same sight would excite the *appetite* of the omnivorous pig as well as of the carnivorous puppy. Artificial preparation, spices, etc., may disguise the natural taste of meat, as of coffee or wine, but they will not alter its effect upon the animal system. The flesh-food fallacy, like other errors of the civilized nations, has found plausible defenders, but their principal argument is clearly based on a misunderstood fact. The delusion originated in England, where the *physique* of the beef-fed and rubicund Saxon squire contrasts strongly with that of the potato-fed Celtic laborer. What this really proves is merely that a mixed diet is superior to a diet of starch and water, for the North-Irish dairyman, who adds milk and butter to his starch, outweighs and outlives the rubicund squire. The matter is this : In a cold climate we can not thrive without a modicum of fat, but that fat need not come from slaughtered animals. In a colder country than England the East-Russian peasant, remarkable for his robust health and longevity, subsists on cabbage-soup, rye bread, and vegetable oils. In a colder country than England the Gothenburg shepherds live chiefly on milk, barley-bread, and esculent roots. The strongest men of the three manliest races of the present world are non-carnivorous: the Turanian mountaineers of Daghestan and Lesghia, the Mandingo tribes of Senegambia, and the Schleswig-Holstein *Bauern*, who furnish the heaviest cuirassiers for the Prussian army and the ablest seamen for the Hamburg navy. Nor is it true that flesh is an indispensable, or even the best, brain-food. Pythagoras, Plato, Seneca, Paracelsus, Spinoza, Peter Bayle, and Shelley were vegetarians ; so were Franklin and Lord Byron in their best years. Newton, while engaged in writing his "Principia" and "Quadrature of Curves," abstained entirely from animal food, which he had found by experience to be unpropitious to severe mental application. The ablest modern physiologists incline to the same opinion. "I use animal food because I have not the opportunity to choose my diet," says Professor Welch, of Yale, "but whenever I have abstained from it, I have found my health mentally, morally, and physically better."

Though a vegetarian on principle, I have eaten various kinds of flesh as a physiological experiment, and have often observed the influence of animal food upon children and invalids, and I have found that a pound of boiled beef or eight ounces of lean pork, after a month's abstinence from all flesh-food, will infallibly produce some or all of the following unmistakable effects : a gastric uneasiness, akin to the incipient operation of certain emetics ; distressing dreams, restlessness, and a peculiar mood which I might describe as a promiscuous pessimism, a feeling of general irritation and resentment. I have also noticed that flesh-food tends to check intellectual activity, not so much by making us averse to all mental occupations as by muddling what phrenologists call the *perceptives.* By its continued use children

gradually lose their native brightness as well as their amiable temper.

But the same observations oblige me to say that its deleterious *physical* effects have often been considerably overrated. The gastric uneasiness, even after a hearty meal of meat (fat pork, perhaps, excepted), yields readily to exercise in open air. Meat does not interfere with the digestion of other food, and, above all, it produces no ruinous after-effects; its frequent use rarely becomes a morbid necessity. Besides, flesh undoubtedly contains many nutritive elements, though in a less desirable form than we might find them in vegetable substances. By dint of practice the system can be got to accept part of its nutriment in that form, and if we are reduced to the choice of starving on starch and watery herbs, or getting fat in an abnormal way, the latter is clearly the preferable alternative. As a rule, though, children during their school years had better stick to dairy products, farinaceous preparations, and fruit; hot-headed boys, especially, can be more effectually cured with cow's-milk than with a cow-hide.

The objections to flesh-food, however, do not apply to eggs, and not in the same degree to mollusks and crustaceans. On the banks of the Essequibo, in eastern Venezuela, I have seen troops of capuchin monkeys (*Cebus paniscus*) engaged in catching crabs, though in captivity those same relatives of ours would rather starve than touch a piece of beef. The dog-headed baboon visits the seashore in search of mollusks, and the South American marmoset, like John the Baptist, delights in grasshoppers and wild honey, though otherwise a strict vegetarian. The mediæval distinction between flesh and fish is not wholly gratuitous, either; carp, trout, and their congeners are, happily, almost as digestible as potatoes, for it would be a hopeless undertaking to dissuade a young Walton from boiling and devouring his first string of perch. On journeys, especially in cold weather, children may be occasionally indulged in such wayside delicacies as codfish-balls, oiled sardines, and ham-sandwiches.

THE SABBATH.

By Professor JOHN TYNDALL, F. R. S.

II.

THE moods of the times—the "climates of opinion," as Glanvil calls them—have also to be considered in imposing disciplines which affect the public. For the ages, like the individual, have their periods of mirth and earnestness, of cheerfulness and gloom. From this point of view a better case might be made out for the early Sabbatarians than for their survivals at the present day. Sunday sports

had grown barbarous; bull- and bear-baiting, interludes, and bowling were reckoned among them, and the more earnest spirits longed not only to promote edification but to curb excess. Sabbatarianism, therefore, though opposed, made rapid progress. Its opponents did what religious parties, when in power, always do—exercised that power tyrannically. They invoked the arm of the flesh to suppress or change conviction. In 1618 James I published a declaration, known afterward as "The Book of Sports," because it had reference to Sunday recreations. Puritan magistrates had interfered with the innocent amusements of the people, and the King wished to insure their being permitted after divine service to those who desired them; but not enjoined upon those who did not. Coarser sports, and sports tending to immorality, were prohibited. Charles I renewed the declaration of his father. Not content, however, with expressing his royal pleasure—not content with restraining the arbitrary civil magistrate—the King decreed that the declaration should be published "through all the parish churches," the bishops in their respective dioceses being made the vehicles of the royal command. Defensible in itself, the declaration thus became an instrument of oppression. The High Church party, headed by Archbishop Laud, forced the reading of the documents on men whose consciences recoiled from the act. "The precise clergy," as Hallam calls them, refused in general to comply, and were suspended or deprived in consequence. "But," adds Hallam, "mankind loves sport as little as prayer by com*p*ulsion; and the immediate effect of the King's declaration was to produce a far more scrupulous abstinence from diversions on Sundays than had been practiced before."

The Puritans, when they came into power, followed the evil example of their predecessors. They, the champions of religious freedom, showed that they could, in their turn, deprive their antagonists of their benefices, fine them, burn their books by the common hangman, and compel them to read from the pulpit things of which they disapproved. On this point Bishop Heber makes some excellent remarks. "Much," he says, "as each religious party in its turn had suffered from persecution, and loudly and bitterly as each had, in its own particular instance, complained of the severities exercised against its members, no party had yet been found to perceive the great wickedness of persecution in the abstract, or the moral unfitness of temporal punishment as an engine of religious controversy." In a very different strain writes the Dr. Bownd who has been already referred to as a precursor of Puritanism. He is so sure of his "doxy" that he will unflinchingly make others bow to it. "It behooveth," he says, "all kings, princes, and rulers that profess the true religion, to enact such laws, and to see them diligently executed, whereby the honor of God in hallowing these days might be maintained. And, indeed, this is the chiefest end of all government, that men might not profess what re-

ligion they list, and serve God after what manner it pleaseth them best, but that the parts of God's true worship [Bowndean worship] might be set up everywhere, and all men compelled to stoop unto it."

There is, it must be admitted, a sad logical consistency in the mode of action advocated by Dr. Bownd and deprecated by Bishop Heber. As long as men hold that there is a hell to be shunned, they seem logically warranted in treating lightly the claims of religious liberty upon earth. They dare not tolerate a freedom whose end they believe to be eternal perdition. Cruel they may be for the moment, but a passing pang vanishes when compared with an eternity of pain. Unreligious men might call it hallucination, but if I accept undoubtingly the doctrine of eternal punishment, then, whatever society may think of my act, I am self-justified not only in "letting" but in destroying that which I hold dearest, if I believe it to be thereby stopped in its progress to the fires of hell. Hence, granting the assumptions common to both, the persecution of Puritans by High Churchmen, and of High Churchmen by Puritans, had a basis in reason. I do not think the question can be decided on *a priori* grounds, as Bishop Heber seemed to suppose. It is not the abstract wickedness of persecution, so much as our experience of its results, that causes us to set our faces against it. It has been tried, and found the most ghastly of failures. This experimental fact overwhelms the plausibilities of logic, and renders persecution, save in its meaner and stealthier aspects, in our day impossible.

The combat over Sunday continued, the Sabbatarians continually gaining ground. In 1643 the divines who drew up the famous document known as the Westminster Confession began their sittings in Henry VII's Chapel. Milton thought lightly of these divines, who, he said, were sometimes chosen by the whim of members of Parliament; but the famous Puritan, Baxter, extolled them for their learning, godliness, and ministerial abilities. A journal of their earlier proceedings was kept by one of their members. On the 13th of November, 1644, he records the occurrence of "a large debate" on the sanctification of the Lord's day. After fixing the introductory phraseology, the assembly proceeded to consider the second proposition, "To abstain from all unnecessary labors, worldly sports, and recreations." It was debated whether "worldly thoughts" should not be added. "This was scrupulous," says the *naïve* journalist, "whether we should not be a scorn to go about to bind men's thoughts, but at last it was concluded upon to be added, both for the more piety and for that the fourth command includes it." The question of Sunday cookery was then discussed and settled; and, as regards public worship, it was decreed "that all the people meet so timely that the whole congregation be present at the beginning, and not depart until after the blessing. That what time is vacant between or after the solemn meetings of the congregation be spent in reading, meditation, repetition of sermons,"

etc. These holy men were full of that strength already referred to as imparted by faith. They needed no natural joy to brighten their lives, mirth being displaced by religious exaltation. They erred, however, in making themselves a measure for the world at large, and insured the overthrow of their cause by drawing too heavily upon average human nature. "This much," says Hallam, "is certain, that when the Puritan party employed their authority in proscribing all diversions, and enforcing all the Jewish rigor about the Sabbath, they rendered their own yoke intolerable to the young and gay; nor did any other cause, perhaps, so materially contribute to bring about the Restoration."

In 1646, the "Confession" being agreed upon, it was presented to Parliament, which, in 1648, accepted and published its doctrinal portion. There was no lack of definiteness in the Assembly's statements. They spoke as confidently of the divine enactments as if each member had been personally privy to the counsels of the Most High. When Luther in the Castle of Marburg had had enough of the arguments of Zuinglius on the "real presence," he is said to have ended the controversy by taking up a bit of chalk and writing firmly and finally upon the table, "*Hoc est corpus meum.*" Equally downright and definite were the divines at Westminster. They were modest in offering their conclusions to Parliament as "humble advice," but there was no flicker of doubt either in their theology or their cosmology. "From the beginning of the world," they say, "to the resurrection of Christ the last day of the week was kept holy as a Sabbath"; while from the resurrection it "was changed into the first day of the week, which in Scripture is called the Lord's day, and is to be continued to the end of the world as the Christian Sabbath." The notions of the divines regarding the "beginning and the end" of the world were primitive but decided. An ancient philosopher was once mobbed for venturing the extravagant opinion that the sun, which appeared to be a circle less than a yard in diameter, might really be as large as the whole country of Greece. Imagine a man with the knowledge of a modern geologist uttering his blasphemies among these Westminster divines! "It pleased God," they continue, "at the beginning, to create, or make of nothing, the world and all things therein, whether visible or invisible, in the space of six days, and all very good." Judged from our present scientific standpoint, this, of course, is mere nonsense. But the calling of it by this name does not exhaust the question. The real point of interest to me, I confess, is not the cosmological errors of the Assembly, but the hold which theology has taken of the human mind, and which enables it to survive the ruin of what was long deemed essential to its stability. On this question of "essentials" the gravest mistakes are constantly made. Save as a passing form, no part of objective religion is essential. Religion lives not by the force and aid of dogma, but because it is ingrained in the nature of man. To draw

a metaphor from metallurgy, the molds have been broken and reconstructed over and over again, but the molten ore abides in the ladle of humanity. An influence so deep and permanent is not likely soon to disappear; but of the future form of religion little can be predicted. Its main concern may possibly be to purify, elevate, and brighten the life that now is, instead of treating it as the more or less dismal vestibule of a life that is to come.

The term "nonsense," which has been just applied to the views of creation enunciated by the Westminster Assembly, was used, as already stated, in reference to our present knowledge and not to the knowledge of three or four centuries ago. To most people the earth was at that time all in all; the sun and moon and stars being set in heaven merely to furnish lamplight to our planet. But though in relation to the heavenly bodies the earth's position and importance were thus exaggerated, very inadequate and erroneous notions were entertained regarding the shape and magnitude of the earth itself. Theologians were horrified when first informed that our planet was a sphere. The question of antipodes exercised them for a long time, most of them pouring ridicule on the idea that men could exist with their feet turned toward us, and with their heads pointing downward. I think it is Sir George Airy who refers to the case of an over-curious individual asking what we should see if we went to the edge of the world and looked over. That the earth was a flat surface on which the sky rested was the belief entertained by the founders of all our great religious systems. Even liberal Protestant theologians stigmatized the Copernican theory as being "built on fallible phenomena and advanced by many arbitrary assumptions against evident testimonies of Scripture." * Newton finally placed his intellectual crowbar beneath these ancient notions, and heaved them into irretrievable ruin.

Then it was that penetrating minds, seeing the nature of the change wrought by the new astronomy in our conceptions of the universe, also discerned the difficulty, if not the impossibility, of accepting literally the Mosaic account of creation. They did not reject it, but they assigned to it a meaning entirely new. Dr. Samuel Clarke, who was the personal friend of Newton and a supporter of his theory, threw out the idea that "possibly the six days of creation might be a typical representation of some greater periods." Clarke's contemporary, Dr. Thomas Burnet, wrote with greater decision in the same strain. The Sabbath being regarded as a shadow or type of that heavenly repose which the righteous will enjoy when this world has passed away, "so these six days of creation are so many periods or millenniums for which the world and the toils and labors of our present state are destined to endure." † The Mosaic account was thus reduced

* Such was the view of Dr. John Owen, who is described by Cox as "the most eminent of the Independent divines."

† Cox, vol. ii, p. 211, note.

to a poetic myth—a view which afterward found expression in the vast reveries of Hugh Miller. But if this symbolic interpretation, which is now generally accepted, be the true one, what becomes of the Sabbath-day? It is absolutely without ecclesiastical meaning; and the man who was executed for gathering sticks on that day must be regarded as the victim of a rude legal rendering of a religious epic.

There were many minor offshoots of discussion from the great central controversy. Bishop Horsley had defined a day "as consisting of one evening and one morning, or, as the Hebrew words literally import, of the decay of light and the return of it." But what then, it was asked, becomes of the Sabbath in the Arctic regions, where light takes six months to "decay," and as long to "return"? Differences of longitude, moreover, render the observance of the Sabbath at the same hours impossible. To some people such questions might appear trifling; to others they were of the gravest import. Whether the Sabbath should stretch from sunset to sunset, or from midnight to midnight, was also a subject of discussion. Voices, moreover, were heard refusing to acknowledge the propriety of the change from Saturday to Sunday, and the doctrine of Seventh-day observance was afterward represented by a sect.* The earth's sphericity and rotation, which had at first been received with such affright, came eventually to the aid of those afflicted with qualms and difficulties regarding the respective claims of Saturday and Sunday. The sun apparently moves from east to west. Suppose, then, we start on a voyage round the world in a westerly direction. In doing so we sail away, as it were, from the sun, which follows and periodically overtakes us, reaching the meridian of our ship each succeeding day somewhat later than if we stood still. For every 15° of longitude traversed by the vessel the sun will be exactly an hour late; and after the ship has traversed twenty-four times 15°, or 360°, that is to say, the entire circle of the earth, the sun will be exactly a day behind. Here, then, is the expedient suggested by Dr. Wallis, F. R. S., Savilian Professor of Geometry in the University of Oxford, to quiet the minds of those in doubt regarding Saturday observance. He recommends them to make a voyage round the world, as Sir Francis Drake did, "going out of the Atlantic Ocean westward by the Straits of Magellan to the East Indies, and then from the east, returning by the Cape of Good Hope homeward, and let them keep their Saturday-Sabbath all the

* Theophilus Brabourne, a sturdy Puritan minister of Norfolk, whom Cox regards as the founder of this sect, thus argued the question in 1628: "And now let me propound unto your choice these two days: the Sabbath-day on Saturday or the Lord's day on Sunday; and keep whether of the twain you shall in conscience find the more safe. If you keep the Lord's day, but profane the Sabbath-day, you walk in great danger and peril (to say the least) of transgressing one of God's eternal and inviolable laws—the fourth commandment. But, on the other side, if you keep the Sabbath-day, though you profane the Lord's day, you are out of all gunshot and danger, for so you transgress no law at all, since neither Christ nor his apostles did ever leave any law for it."

way. When they come home to England they will find their Saturday to fall upon our Sunday, and they may thenceforth continue to observe their Saturday-Sabbath on the same day with us!"

Large and liberal minds were drawn into this Sabbatarian conflict, but they were not the majority. Between the booming of the bigger guns we have an incessant clatter of small-arms. We ought not to judge superior men without reference to the spirit of their age. This is an influence from which they can not escape, and so far as it extenuates their errors it ought to be pleaded in their favor. Even the atrocities of the individual excite less abhorrence when they are seen to be the outgrowth of his time. But the most fatal error that could be committed by the leaders of religious thought is the attempt to force into their own age conceptions which have lived their life, and come to their natural end, in preceding ages. History is the record of a vast experimental investigation—of a search by man after the best conditions of existence. The Puritan attempt was a grand experiment. It had to be made. Sooner or later the question must have forced itself upon earnest believers possessed of power, Is it not possible to rule the world in accordance with the wishes of God as revealed in the Bible? Is it not possible to make human life the copy of a divine pattern? The question could only have occurred in the first instance to the more exalted minds. But, instead of working upon the inner forces and convictions of men, legislation presented itself as a speedier way to the attainment of the desired end. To legislation, therefore, the Puritans resorted. Instead of guiding, they repressed, and thus pitted themselves against the unconquerable impulses of human nature. Believing that nature to be depraved, they felt themselves logically warranted in putting it in irons. But they failed; and their failure ought to be a warning to their successors.

Another error, of a far graver character than that just noticed, may receive a passing mention here. At the time when the Sabbath controversy was hottest, and the arm of the law enforcing the claims of the Sabbath strongest and most unsparing, another subject profoundly stirred the religious mind of Scotland. A grave and serious nation, believing intensely in its Bible, found therein recorded the edicts of the Almighty against witches, wizards, and familiar spirits, and were taught by their clergy that such edicts still held good. The same belief had overspread the rest of Christendom, but in Scotland it was intensified by the rule of Puritanism and the natural earnestness of the people. I have given you a sample of the devilish cruelties practiced on the Christians at Smyrna. These tortures were far less shocking than those inflicted upon witches in Scotland. I say less shocking, because the victims at Smyrna courted martyrdom. They counted the sufferings of this present time as not worthy to be compared with the glory to be revealed; while the sufferers for witchcraft, in the midst of all their agonies, felt themselves God-forsaken, and

saw before them instead of the glories of heaven the infinite tortures of hell. Not to the fall of Sarmatia, but to the treatment of witches in the seventeenth century, ought to be applied the words of your poet Campbell :

"Oh! bloodiest picture in the book of time!"

The mind sits in sackcloth and ashes while contemplating the scenes so powerfully described by Mr. Lecky in his chapter on "Magic and Witchcraft." But I will dwell no further upon these tragedies than to point out how terrible are the errors which our clergy may commit after they have once subscribed to the creed and laws of Judaism, and constituted themselves the legal exponents and interpreters of those laws.*

Turning over the leaves of the Pentateuch, where God's alleged dealings with the Israelites are recorded, it strikes one with amazement that such writings should be considered binding upon us. The overmastering strength of habit, the power of early education—possibly a defiance of the claims of reason involved in the very constitution of the mental organ—are illustrated by the fact that learned men are still to be found willing to devote their time and endowments to these writings, under the assumption that they are not human but divine. As an ancient book, claiming the same origin as other books, the Old Testament is without a rival, but its unnatural exaltation provokes recoil and rejection. Leviticus, for example, when read in the light of its own age, is full of interest and instruction. We see there described the efforts of the best men then existing to civilize the rude society around them. Violence is restrained by violence medicinally applied. Passion is checked, truth and justice are extolled, and all in a manner suited to the needs of a barbarian host. But read in the light of our age, its conceptions of the Deity are seen to be shockingly mean, and many of its ordinances brutal. Foolishness is far too weak a word to apply to any attempt to force upon a scientific age the edicts of a Jewish law-giver. The doom of such an attempt is sure ; and, if the destruction of things really precious should be involved in its failure, the blame will justly be ascribed to those who obstinately persisted in the attempt. Let us, then, cherish our Sunday as an inheritance derived from the wisdom of the past ; but let it be understood that we cherish it because it is in principle reasonable and in practice salutary. Let us uphold it, because it commends itself to that "light of nature" which, despite the catastrophe in Eden, the most famous theologians mention with respect, and not because it is enjoined by the thunders of Sinai. We have surely heard enough of divine sanctions founded upon myths which, however beautiful and touching when regarded from the proper point of view, are seen, when cited

* The sufferings of reputed witches in the seventeenth century, as well as those of the early Christians, might be traced to panics and passions similar in kind to those which produced the atrocities of the Reign of Terror in France.

for our guidance as matters of fact, to offer warrant and condonation for the greatest crimes, or to sink to the level of the most palpable absurdities.*

In this, as in all other theological discussions, it is interesting to note how character colors religious feeling and conduct. The reception into Christ's kingdom has been emphatically described as being born again. A certain likeness of feature among Christians ought, one would think, to result from a common spiritual parentage. But the likeness is not observed. Christian communities embrace some of the loftiest and many of the lowest of mankind. It may be urged that the lofty ones only are truly religious. To this it is to be replied that the others are often as religious as their natures permit them to be. *Character* is here the overmastering force. That religion should influence life in a high way implies the preëxistence of natural dignity. This is the mordant which fixes the religious dye. He who is capable of feeling the finer glow of religion would possess a substratum available for all the relations of life, even if his religion were taken away. Religion, on the other hand, does not charm away malice, or make good defects of character. I have already spoken of persecution in its meaner forms. On the lower levels of theological warfare such are commonly resorted to. If you reject a dogma on intellectual grounds, it is because there is a screw loose in your morality; some personal sin besets and blinds you; the intellect is captive to a corrupt heart. Thus good men have been often calumniated by others who were not good; thus frequently have the noble become a target for the wicked and the mean. With the advance of public intelligence the day of such assailants is happily drawing to a close.

These reflections, which connect themselves with reminiscences outside the Sabbath controversy, have been more immediately prompted by the aspersions cast by certain Sabbatarians upon those who differ from them. Mr. Cox notices and reproves some of these. According to the Scottish Sabbath Alliance, for example, all who say that the Sabbath was an exclusively Jewish institution, including, be it noted, such men as Jeremy Taylor and Milton, "clearly prove either their *dishonesty* or ignorance, or inability to comprehend a very plain and simple subject." This becomes real humor when we compare the speakers with the persons spoken of. A distinguished English dissenter, who deals in a lustrous but rather cloudy logic, declares that whoever asks demonstration of the divine appointment of the Christian Sabbath "is

* Melanchthon writes finely thus: "Wherefore our decision is this: that those precepts which learned men have committed to writing, transcribing them from the common reason and common feelings of human nature, are to be accounted as no less divine than those contained in the tables of Moses."—(Dugald Stewart's translation.) Hengstenberg quotes from the same reformer as follows: "The law of Moses is not binding upon us, though some things which the law contains are binding, because they coincide with the law of nature."—(See Cox, vol. i, p. 389.) The Catechism of the Council of Trent expresses a similar view. There are, then, "data of ethics" over and above the revealed ones.

blinded *by a moral cause* to those exquisite pencilings, to those unobtruded vestiges, which furnish their clearest testimony to this institute." A third writer charitably professes his readiness "to admit, in reference to this and many other duties, that it is quite a possible thing for a mind that is desirous of *evading the evidence* regarding it to succeed in doing so." A fourth luminary, whose knowledge obviously extends to the mind and methods of the Almighty, exclaims, "Is it not a principle of God's Word in many cases to give enough and no more—to satisfy the devout, not to overpower the *uncandid?*" It is of course as easy as it is immoral to argue thus; but the day is fast approaching when the most atrabilious presbyter will not venture to use such language. Let us contrast with it the utterance of a naturally sweet and wholesome mind. "Since all Jewish festivals, new moons, and Sabbaths," says the celebrated Dr. Isaac Watts, "are abolished by St. Paul's authority; since the religious observation of days in the fourteenth chapter to the Romans, in general, is represented as a matter of doubtful disputation; since the observation of the Lord's day is not built upon any express or plain institution by Christ or his apostles in the New Testament, but rather on examples and probable inferences, and on the reasons and relations of things—I can never pronounce anything hard or severe upon any fellow-Christian who maintains real piety in heart and life, though his opinion on this subject may be very different from mine." Thus through the theologian radiates the gentleman.

Up to the end of the eighteenth century the catalogue of Mr. Cox embraces three hundred and twenty volumes and publications. It is a monument of patient labor; while the remarks of the writer, which are distributed throughout the catalogue, illustrate both his intellectual penetration and his reverent cast of mind. He wrought hard and worthily with a pure and noble aim. I had the pleasure of meeting Mr. Cox at Dundee in 1867, when the British Association met there, and I could then discern the earnestness with which he desired to see his countrymen relieved from the Sabbath incubus, and at the same time the moderation and care for the feelings of others with which he advocated his views. He has also given us a rapid "Sketch of the Chief Controversies about the Sabbath in the Nineteenth Century." The sketch is more compressed than the catalogue, and the changes of thought in passing from author to author, being more rapid, are more bewildering. It is to a great extent what I have already called a clatter of small-arms, mingled with the occasional discharges of mightier guns. One thing is noticeable and regrettable in these discussions, namely, the unwise and undiscriminating way in which different Sunday occupations are classed together and condemned. Bishop Blomfield, for example, seriously injures his case when he places drinking in gin-shops and sailing in steamboats in the same category. I remember some years ago standing by the Thames at Putney with my

lamented friend Dr. Bence Jones, when a steamboat on the river, with its living freight, passed us. Practically acquainted with the moral and physical influence of pure oxygen, my friend exclaimed, "What a blessing for these people to be able thus to escape from London into the fresh air of the country!" I hold the physician to have been right, and, with all respect, the Bishop to have been wrong.

Bishop Blomfield also condemns resorting to tea-gardens on Sunday. But we may be sure that it is not the gardens, but the minds which the people bring to them, which produce disorder. These minds possess the culture of the city, to which the Bishop seems disposed to confine them. Wisely and soberly conducted—and it is perfectly possible to conduct them wisely and soberly—such places might be converted into aids toward a life which the Bishop would commend. Purification and improvement are often possible where extinction is neither possible nor desirable. I have spent many a Sunday afternoon in the public gardens of the little university town of Marburg, in the company of intellectual men and cultivated women, without observing a single occurrence which, as regards morality, might not be permitted in the Bishop's drawing-room. I will add to this another observation made at Dresden on a Sunday after the suppression of the insurrection by the Prussian soldiery in 1849. The victorious troops were encamped on the banks of the Elbe, and this is how they occupied themselves: Some were engaged in physical games and exercises which in England would be considered innocent in the extreme; some were conversing sociably; some singing the songs of Uhland, while others, from elevated platforms, recited to listening groups poems and passages from Goethe and Schiller. Through this crowd of military men passed and repassed the girls of the city, linked together with their arms round each other's necks. During hours of observation, I heard no word which was unfit for a modest ear; while from beginning to end I failed to notice a single case of intoxication.*

Here we touch the core of the whole matter—the appeal to experience. Sabbatical rigor has been tried, and the question is, Have its results been so conducive to good morals and national happiness as to render criminal every attempt to modify it? The advances made in all kinds of knowledge in this our age are known to be enormous; and the public desire for instruction, which the intellectual triumphs of the time naturally and inevitably arouse, is commensurate with the growth of knowledge. Must this desire, which is the motive power of all real and healthy progress, be quenched or left unsatisfied, lest Sunday observances, unknown to the early Christians, repudiated by the heroes of the Reformation, and insisted upon for the first time during a period of national gloom and suffering in the seventeenth century, should be

* The late Mr. Joseph Kay, as Traveling Bachelor of the University of Cambridge, has borne strong and earnest testimony to the "humanizing and civilizing influence" of the Sunday recreations of the German people.

interfered with? To justify this position the demonstration of the success of Sabbatarianism must be complete. Is it so? Are we so much better than other nations who have neglected to adopt our rules, that we can point to the working of these rules in the past as a conclusive reason for maintaining them immovable in the future? The answer must be, No. My Sabbatarian friends, you have no ground to stand upon. I say friends, for I would far rather have you as friends than as enemies—far rather see you converted than annihilated. You possess a strength and earnestness with which the world can not dispense; but, to be productive of anything permanently good, that strength and earnestness must build upon the sure foundation of human nature. This is that law of the universe spoken of so frequently by your illustrious countryman, Mr. Carlyle, to quarrel with which is to provoke and precipitate ruin. Join with us, then, in our endeavors to turn our Sundays to better account. Back with your support the moderate and considerate demands of the Sunday Society, which scrupulously avoids interfering with the hours devoted by common consent to public worship. Offer the museum, the picture-gallery, and the public garden as competitors to the public-house. By so doing you will fall in with the spirit of your time, and row with, instead of against, the resistless current along which man is borne to his destiny.

Most of you here are Liberals; perhaps Radicals, perhaps even Democrats or Republicans. I am a Conservative. The first requisite of true conservatism is foresight. Humanity grows, and foresight secures room for future expansion. In your walks in the country you sometimes see a wall built round a growing tree. So much the worse for the wall, which is sure to be rent and ruined by the energy which it opposes. We have here represented not a true, but a false and ignorant conservatism. The real conservative looks ahead and prepares for the inevitable. He forestalls revolution by securing, in due time, sufficient amplitude for the national vibrations. He is a wrong-headed statesman who imposes his notions, however right in the abstract, on a nation unprepared for them. He is no statesman at all who, without seeking to interpret and guide it in advance, merely waits for the more or less coarse expression of the popular will, and then constitutes himself its vehicle. *Untimeliness* is sure to be the characteristic of the work of such a statesman. In virtue of the position which he occupies, his knowledge and insight ought to be in advance of the public knowledge and insight; and his action, in like degree, ought to precede and inform public action. This is what I want my Sabbatarian friends to bear in mind. If they look abroad from the vantage-ground which they occupy, they can hardly fail to discern that the intellect of this country is gradually ranging itself upon our side. Statesmen, clergymen, philosophers, and moralists are joining our standard. Whether, therefore, those to whom I appeal hear, or whether they forbear, we are sure to unlock, for the public

good, the doors of the museums and galleries which we have purchased, and for the maintenance of which we pay. But I would have them not only prepare for the coming change, but to aid and further it by anticipation. They will thus, in a new fashion, "dish the Whigs," prove themselves men of foresight and common sense, and obtain a fresh lease of the respect of the community.

As the years roll by, the term "materialist" will lose more and more of its evil connotation; for it will be more and more seen and acknowledged that the true spiritual nature of man is bound up with his material condition. Wholesome food, pure air, cleanliness—hard work if you will, but also fair rest and recreation—these are necessary not only to physical but to spiritual well-being. The seed of the spirit is cast in vain amid stones and thorns, and thus your best utterances become idle words when addressed to the acclimatized inhabitants of our slums and alleys. Drunkenness ruins the substratum of resolution. The physics of the drunkard's brain are incompatible with moral strength. Here your first care ought to be to cleanse and improve the organ. Break the sot's associations; change his environment; alter his nutrition; displace his base imaginations by thoughts drawn from the purer sources which we seek to render accessible to him. For two centuries, I am told, the Scottish clergy have proclaimed walking on Sunday to be an act of "Heaven-daring profaneness—an impious encroachment on the inalienable prerogative of the Lord God." Such language is now out of date. If we could establish Sunday tramways between our dens of filth and iniquity and the nearest green fields, we should, in so doing, be preaching a true gospel. And not only the denizens of our slums, but the proprietors of our factories and counting-houses, might perhaps be none the worse for an occasional excursion in the company of those whom they employ. A most blessed influence would also be shed upon the clergy if they were enabled from time to time to change their "sloth urbane" for healthy action on heath or mountain. Baxter was well aware of the soothing influence of fields, and countries, and walks, and gardens on a fretted brain. Jeremy Taylor showed a profound knowledge of human nature when he wrote thus: "It is certain that all which can innocently make a man cheerful, does also make him charitable. For grief, and age, and sickness, and weariness, these are peevish and troublesome; but mirth and cheerfulness are content, and civil, and compliant, and communicative, and love to do good, and swell up to felicity only upon the wings of charity. Upon this account, here is pleasure enough for a Christian at present; and if a facete discourse, and an amicable friendly mirth, can refresh the spirit and take it off from the vile temptation of peevish, despairing, uncomplying melancholy, it must needs be innocent and commendable." I do not know whether you ever read Thomas Hood's "Ode to Rae Wilson," with an extract from which I will close this address. Hood was a humorist, and to some of our graver theologians

might appear a mere feather-head. But those who have read his more serious works will have discerned in him a vein of deep poetic pathos. I hardly know anything finer than the apostrophe in which he turns from those

> "That bid you balk
> A Sunday walk,
> And shun God's work as you should shun your own"—

to the description of what Sunday might be, and is, to him who is competent to enjoy it aright :

> "Thrice blessed, rather, is the man, with whom
> The gracious prodigality of nature,
> The balm, the bliss, the beauty, and the bloom,
> The bounteous providence in every feature,
> Recall the good Creator to his creature,
> Making all earth a fane, all heaven its dome !
> To *his* tuned spirit the wild heather-bells
> Ring Sabbath knells ;
> The jubilate of the soaring lark
> Is chant of clerk ;
> For choir, the thrush and the gregarious linnet ;
> The sod's a cushion for his pious want ;
> And, consecrated by the heaven within it,
> The sky-blue pool, a font.
> Each cloud-capped mountain is a holy altar ;
> An organ breathes in every grove ;
> And the full heart's a Psalter,
> Rich in deep hymns of gratitude and love ! "

—*Nineteenth Century.*

DOMESTIC MOTORS.

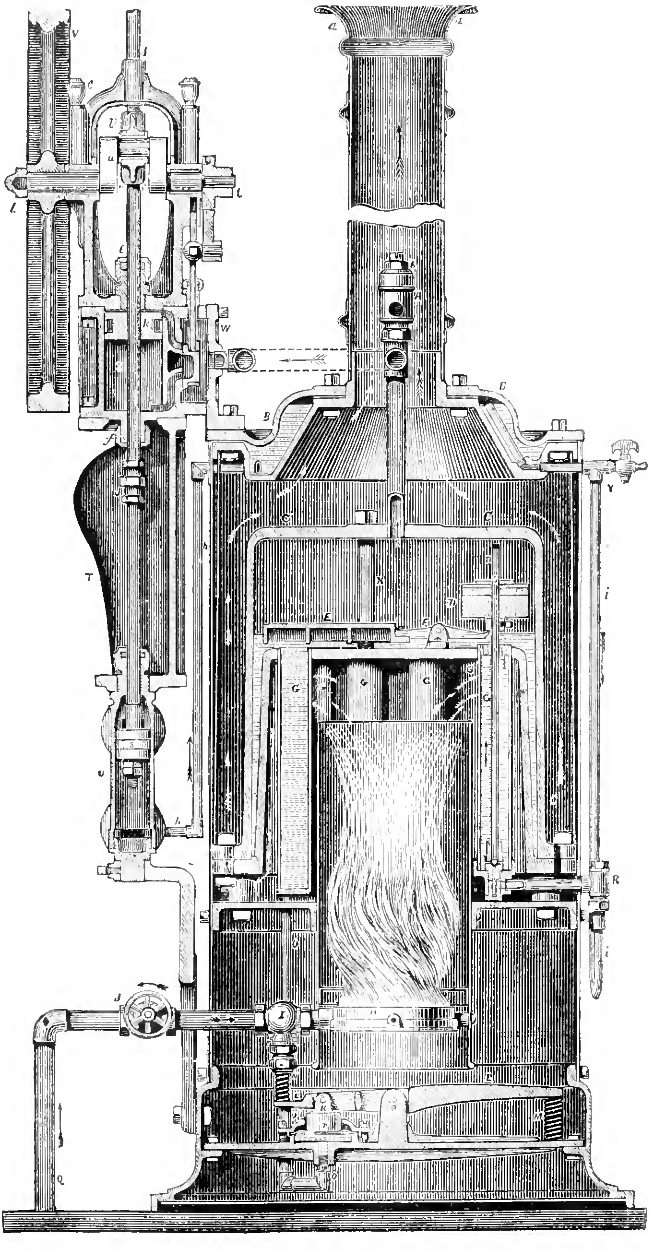
By CHARLES M. LUNGREN.

II.—STEAM AND HOT-AIR ENGINES.

SMALL steam-engines of from two to ten horse-power are made by a number of engine-builders, and are quite extensively used. They are of varied excellence, like those of larger size, and are well enough known to need no description here. Those of powers of one horse and under suitable for use in the household, for amateurs, etc., are, however, comparatively rare. The danger of explosion, and the requirement of skilled attendants, which in cities the law in consequence imposes, have operated to prevent their use ; while, on account of the but little greater cost of the larger and more serviceable machines, makers have preferred to construct the latter. Some of these small engines are, however, made, two of the best designs of which, the invention of Mr. H. S. Maxim, are shown in Figs. 4 and 5. The one illustrated in

the first engraving is constructed for pumping purposes only, and that in Fig. 5 for power. Both forms use gas in the smaller sizes, and are entirely automatic in their action. They are compact, highly finished,

Fig. 4.

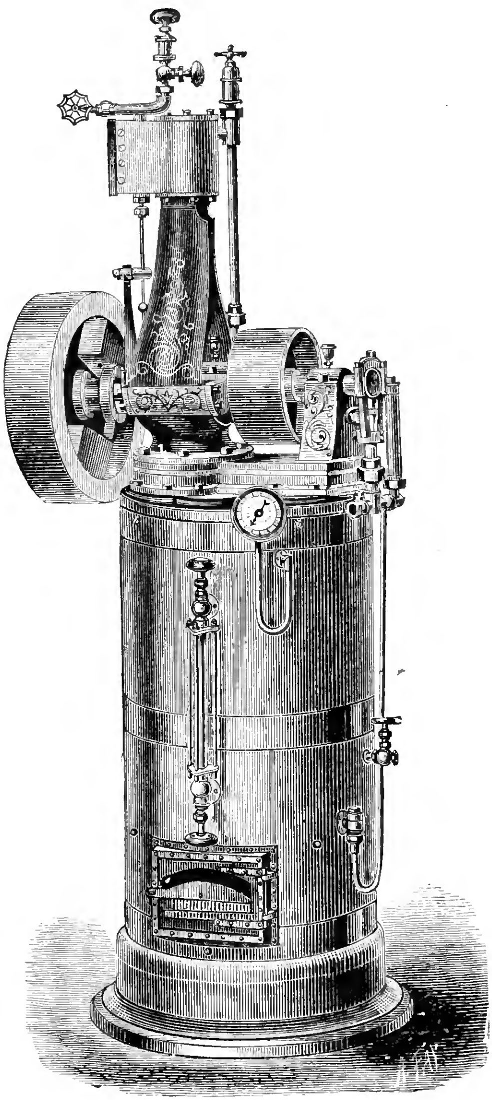


and can be used anywhere in a house without annoyance, as they run with almost no noise. They occupy but small space, the boiler-casing being in the smallest size but sixteen inches in diameter and three feet in height. The base of the machine has air-spaces to prevent the heat from burning the floor. The construction and operation of the pumping-engine will be clear from an inspection of the cut. The heater B surrounds the boiler C C, which is made with pendent water-tubes G G, among which the burning gases circulate on their way to the smoke-stack. The gas burns from a double argand burner H, the supply being automatically controlled by the steam-pressure in an ingenious manner. At I, a valve is placed in the gas-pipe which is operated by the lever *l*, the longer end of which is pressed up by the spring M. A tube, *o*, leads from the boiler to a chamber in which works the diaphragm-piston *r*, attached to the shorter end of the lever L. If the pressure in the boiler increases, it is transmitted to the piston which rises and partially closes the valve I, diminishing the supply of gas. A lessening of the boiler-pressure produces the reverse effect of increasing the gas-supply. The amount of fuel consumed is thus accurately proportioned to the amount of steam generated by the engine itself. This allows the gas to be kept burning while no work is being done, and consequently no steam used without there being the slightest danger of an explosion, a feature of great value in a power-engine when it is used intermittently, but needs to be in constant readiness. In the larger sizes in which coal is used, the fire is regulated by means of an automatic damper operated in a similar manner to the valve controlling the gas-supply.

The feeding of water to the boiler is also controlled by a very simple automatic arrangement. The feed-water chamber is placed at the top of the heater-shell, where it is exposed to the heat of the issuing products of combustion. A pipe, *h*, is open to both the pump and this chamber. So long as the feed-water heater is but partially filled, water continues to be forced into it by the pump; but, when it becomes full, no more can enter until a portion of it has passed into the boiler. The admittance to this latter is controlled by a float mechanism, E, F, D, operating a valve at the base of the boiler through the medium of the rod *o*. The float E is a flat, inverted vessel, which is partially submerged when the boiler is full. A weight, D, at the other extremity of the lever F, is then able to keep the valve closed; but, as the level of the water sinks, the float drops and the valve is opened by the rod *o*, the pressure produced by the pump forcing water from the feed-heater into the boiler. By these two devices, the one controlling the heat by the steam-pressure so as to keep that pressure constant, and the other regulating the amount of water in the boiler, this steam-engine becomes nearly as safe, and gives as little trouble, as any of the simpler forms of heat-engine using hot air or gas. For still further security a safety-valve is placed in the pipe leading from the boiler,

at A ; and in the engines using coal, the heat of which can not be so perfectly controlled as that of gas, a plug of fusible metal is set into the crown-sheet, which melts when the temperature rises above a certain point, and allows the water to flow out and extinguish the fire.

Fig. 5.

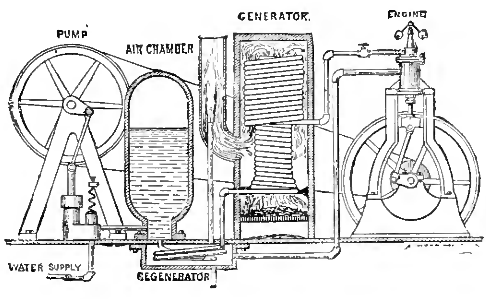


The design of the boiler of the power-engine is somewhat different from that of the pumping one, but the means of automatically regulating both the steam-pressure and the water-supply are substantially the same. This engine has in addition a very ingenious governor which acts

directly upon the point of cut-off as in the best machines of large power. It is placed inside the belt-pulley, and dispenses with the ordinary belt, thereby avoiding the danger of the engine racing through the breaking or slipping of the belt. The balls are two heavy weights revolving with the belt-pulley, and balanced by spiral springs. They are free to move in the direction of the radius of the wheel to and from the center, and, as they do so under variations of speed, they operate the cut-off mechanism in a simple manner. The working of this governor has been found very satisfactory in use, and it seems to be well suited to engines of larger power. This engine is made in sizes of one half, one, one and a half, two, and two and a half horse-power, and up to five horse, while the pumping-engine is made of a capacity of from two hundred and fifty to fifteen hundred gallons per hour, raised one hundred feet high. The former amount is pumped with an expenditure of twenty-five feet of gas an hour. These engines have been on the market some five years, and have been found very satisfactory in use.

An engine of very much smaller power, and quite novel construction, the invention of Mr. Charles Tyson, has very recently been brought out, which seems to be well adapted to driving such light machinery as sewing and knitting machines, lathes, scroll-saws, fans, coffee-mills, etc. It is quite safe, requires but little care, does not easily get out of order, and can be managed by any one capable of using a sewing-machine. It is ornamental in design and handsomely finished, fitting it to be used in any room of a dwelling that is convenient. Those at present made are of about one quarter of a man-power (one thousand foot-pounds per minute), but larger sizes, adapted to a greater range of

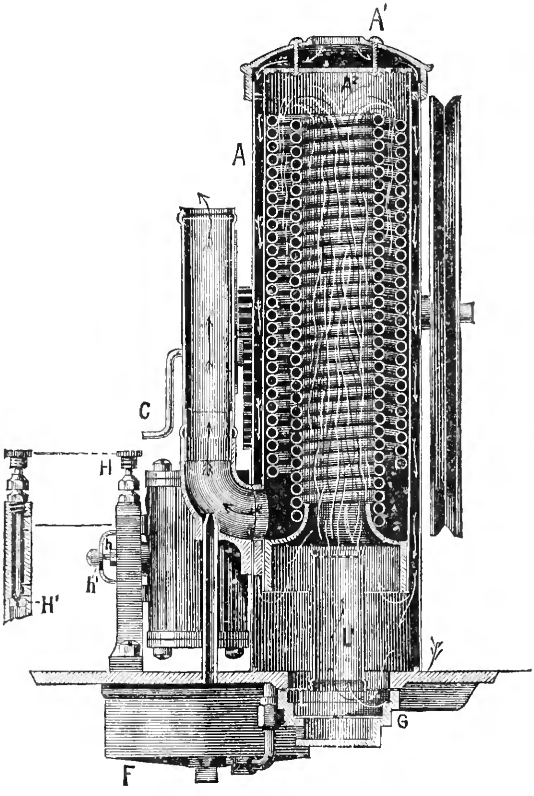
Fig. 6.



work, will probably be built should the present machine prove satisfactory in use. Gas is used as fuel, but they can be made to burn either coal, wood, or oil. The construction and method of generating steam are such that an explosion can not occur, and the steam-gauge, water-gauge, and safety-valve are therefore dispensed with, with the advantage of considerably lessening the cost. The idea carried out in the construction of this engine is that of converting the water into steam in

small amounts at a time. In the steam-engine, large or small, the whole body of water is exposed to the action of the fire, and a considerable quantity of steam is constantly generated. In this, small quantities of water are successively forced from a reservoir through coils of highly heated tubing, and there flashed into steam. A force-pump driven by the engine continually supplies water to the reservoir. The relation of the different parts of the apparatus to each other, and the working of the system, are clearly shown in Fig. 6. The long tubing, in which the water is converted into steam, leads from the air-chamber to the steam-chest of the engine. It is coiled first in a receptacle through which the exhaust steam passes, and then in the generator, where it is as completely as possible exposed to the action of the fire. In starting the engine, the fly-wheel is turned by hand, so as to produce a pressure in

Fig. 7.

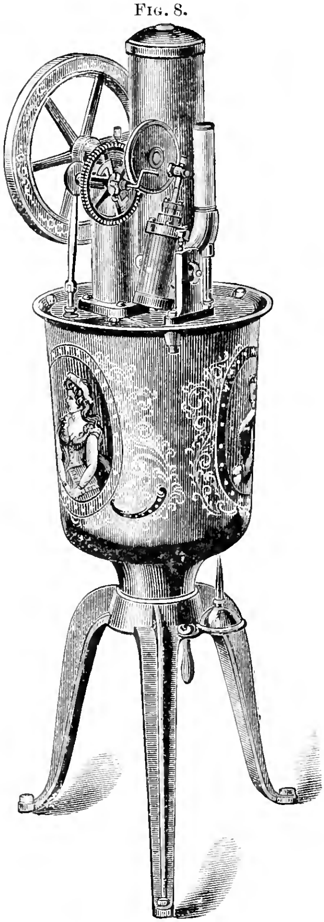


the air-chamber. This forces the water into the coil, where it is rapidly converted into steam, and delivered in the steam-chest at the pressure furnished by the pump. When the engine begins running, it drives the pump and maintains the pressure. If the engine is stopped

and the fire continues to burn, the water in the coil will be forced back into the air-chamber, and the production of steam will cease.

When the water is exhausted, the engine simply stops until the supply is renewed. At the right of the pump a relief-valve is placed to limit the pressure. It is not a safety-valve, as, even if it were absent, an explosion could not occur, as the mechanism of the pump is not strong enough to produce a bursting pressure. The construction of the generator is more fully shown in Fig. 7. It consists of a cylindrical shell in which is coiled about thirty-five feet of seamless copper tubing. In the base of this is a gas-burner, L, and around it is a second shell, leaving an annular space for the entrance of air. The air is also admitted through openings at the bottom of the shell. The burning gases pass up through the center of the coils and down between the two, and out by the draught-pipe. The exhaust steam is discharged through the regenerator, where it partly heats the water in the coil, into this draught-pipe. On first lighting the gas, the cap A′ is removed and the flame allowed to burn up into the air, but as soon as the formation of steam begins the cap is replaced, and the exhaust steam then creates sufficient draught to carry the burning gases through the coils into the draught-pipe. The generator has but one fiftieth the cubical capacity of that required by an ordinary boiler to run the same engine. The engine is of the simple oscillating type, and the whole apparatus is attached to a bed-plate forming the top of a vase-shaped receptacle. Fig. 8 shows the appearance of the complete motor. In another form the vase is supported by a bracket attached to the wall instead of by the tripod. The vase is used to hold the water from which the pump supplies the reservoir. Four or five quarts of water once in as many hours is generally sufficient in the ordinary use of the machine.

Fig. 8.



The engine in this size is far from being economical, requiring twelve cubic feet of gas an hour, while it only furnishes a thirty-third of a horse-power. Efficiency, however, is not very important with such a small motor. This amount of fuel, with

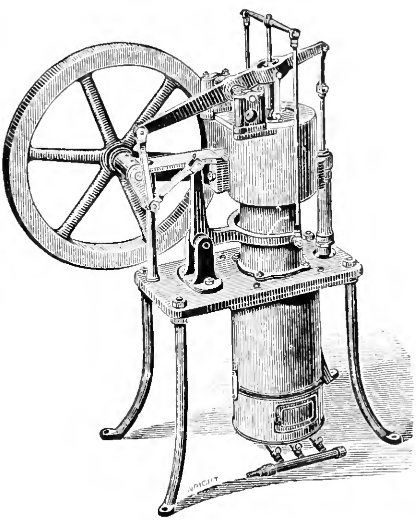
gas at two dollars per thousand, would only cost a little more than two cents an hour, which would make the expense of running a sewing-machine as commonly used inconsiderable. The first cost of the motor is low, while its simplicity of construction should render it quite durable.

The advantages possessed by engines driven by heated air over those using steam, in the matter of safety, absence of the need of skilled attendance, and a possible higher efficiency, early turned the attention of inventors toward the development of this class of motors. Promising as the field seemed, the practical realization of the hopes indulged in has been far short of expectation. The rapid alternate heating and cooling of the air, and the prevention of excessive wear due to traveling surfaces becoming highly heated, have been found to be difficult things to accomplish satisfactorily. On account of the low pressure obtained from heated air, engines of this kind have to be made of such large dimensions that there is little if any gain in compactness over the steam-engine and boiler. This greater size of the working parts also increases friction largely, so much indeed that whatever superior efficiency the hot-air engine may possess, from being able to work between greater extremes of temperature, disappears in the power required to move simply the machine itself. In large powers this engine has never yet been able to compete with the steam-engine, but in small ones it has proved to be quite an economical and serviceable motor. A number of engines of this kind have been invented at different times, and some have gone more or less largely into use. The earliest to excite interest, and to come into a limited use, was that of Rev. Dr. Stirling, in 1816, which was successively improved by him and his brother up to 1840. Among the engines which have been more or less successful have been those of Ericsson, Wilcox, Roper, Shaw, and Rider in this country, and Lauberau and Belou in France. Hot-air engines are broadly divided into two classes by the manner in which they use the air. In one class it is drawn directly from the atmosphere, used, and then discharged. In the other the same body of air is used continuously, being alternately heated and cooled. The latter class has the advantage of being able to use the air at a greater pressure, but they need a refrigerating apparatus, which is unnecessary with the first. When the engine is used for pumping purposes this constitutes no disadvantage, as the water can be passed around the part of the cylinder desired to be kept cool, and even when it is used as a motor, a water circulation can very readily be kept up by means of a supply tank of sufficient capacity. As the efficiency of any heat-engine depends upon the extremes of temperature between which it is worked, either the air used in the air-engine should leave the power-cylinder at the temperature of the atmosphere, or it must be made to give up a portion of its heat to some apparatus that will yield it again to the entering air. The first is impracticable, and attention has there-

fore been given to the construction of such an apparatus, termed a regenerator. This has taken various forms in different machines—from a number of simple perforated plates to nests of tubes. Practically it has been found most economical to attempt to abstract only a part of the heat, as to do more offers too great an obstruction to the passage of the air, with the result of losing as much in power as is gained in heat.

One of the earliest hot-air engines to obtain a recognized place as a valuable aid to motive power was the well-known engine of Ericsson, which has long been on the market, and has come into somewhat general use. It is of the class using a fresh charge of air with each stroke, the air being drawn into the cylinder, compressed, heated, and, after doing its work, discharged. The engine is made both for pumping and power, and is constructed in sizes up to four-horse. It is too well known to require any description here.

FIG. 9.



Quite recently a new and much simpler engine designed for pumping purposes has been perfected by Mr. Ericsson, and is now being manufactured. It belongs to the class in which the same air is used over and over again, being alternately heated and cooled. The cylinder is placed upright, and projects below a table, by which it is supported, into the fire-box placed beneath. This is an iron shell provided with the ordinary grate and brick-lining at its lower end when the fuel used is coal, and with three Bunsen burners when it is gas. The latter fuel is much the most desirable, as it is cleanly, no trouble, and allows of starting and stopping quickly, and of always having the heat under perfect control. The working parts of the engine are a pis-

ton fitting the cylinder tightly, a plunger moving in it loosely, and the system of cranks and connecting-rods by which the motion of these parts is communicated. The upper portion of the cylinder, through which the tightly fitting piston alone moves, is water-jacketed, and consequently remains cool, while the part below this becomes more or less highly heated. In this heated portion the plunger moves, alternately displacing the air from above the fire. It is a long iron shell filled with wool or other non-conductor, and provided with studs on its sides which keep it from the walls of the cylinder. The machine is started by giving a few turns to the fly-wheel, when it begins running of itself, the action being as follows:

The plunger being raised, the air below it is heated and expands, forcing the piston upward. As it does this, the plunger is brought down with a quick motion, displacing the air, which passes through the annular space between the plunger and cylinder wall to the upper part of the cylinder. Here it comes in contact with the cool surface of the water-jacketed portion and contracts, forming a partial vacuum below the piston, which then descends by atmospheric pressure. By the upward movement of the plunger, the air is again brought in contact with the heated bottom and sides of the cylinder, and the same operation is repeated. The plunger-rod passes up through the piston, and by means of the simple system of connecting-rods and cranks shown in the figure the proper motion is given the plunger. The pump is placed at the side of the cylinder, and its rod connected directly to the beam of the engine. The water is drawn into the pump and discharged through the water-jacket, the slight heating of the water in its passage through the jacket being no disadvantage, while the continual passage of fresh water readily keeps the cylinder cool. The engines have so far only been made for pumping purposes, but they can readily be adapted to those of a small power, by using only a part of the power of the engine in pumping. Four sizes of the motor are made, three with single cylinders, six, eight, and twelve inches in diameter, and one with two cylinders of the latter size. The first lifts two hundred gallons of water fifty feet per hour, with an expenditure of fifteen feet of gas, the second three hundred and fifty, the third eight, and the fourth sixteen hundred gallons, the same height, with a proportional consumption of fuel. The prices vary from two hundred and ten dollars for the smaller to five hundred and fifty dollars for the largest size. Only the two smaller sizes are at present made to burn gas. They are perfectly safe, so simple that they can be used by the most inexperienced persons, and for their special purpose are probably as cheap and satisfactory machines as can be made.

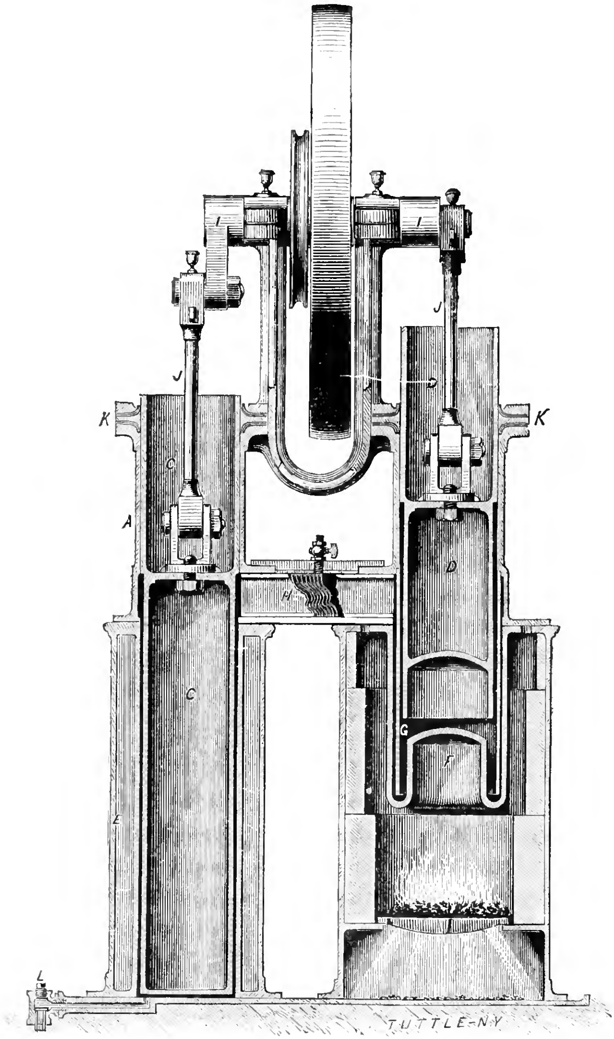
Another engine, and one of the most serviceable of this class of machines to be found in the market, is the Rider compression engine. Like the other hot-air engines, it is constructed chiefly with a view to pumping, but when desired for power in addition it may be ob-

tained fitted with a governor and the necessary pulleys at a slight increase of cost. The pumping-engines have found their way into very general use on railroads, country seats, and in city buildings, and from their economy in the use of fuel and their little trouble they have in all these situations proved very satisfactory. They are made only with coal-burning furnaces, and are on this account more troublesome than they would be if using gas, but are still but little more so than an ordinary coal-stove. Replenishing of fires and oiling are the only duties to be performed, and these can be done by unskilled labor. The engine occupies about the same floor-space as a moderately large coal-stove, and is about the same height. Two sizes are made, one of six, and one of ten-inch cylinder. The former will pump five thousand gallons of water to a height of ten feet in an hour, or a smaller amount to a proportionally greater height, at an expenditure of four pounds of coal, and the latter will raise twelve thousand gallons to the same height, in the same time, with eight pounds of coal. These amounts of coal are those used when the engine is run consecutively for ten hours. If run for a shorter time, the coal consumed per hour will be somewhat greater, owing to the starting of the fire. The engines weigh considerable, the smaller size being some sixteen hundred pounds, and the larger about double. The prices do not differ materially from those of steam-engines of from one to three horse-power.

The internal construction of the engine and manner of working are shown in the sectional view in Fig. 10. It is also of the type which repeatedly uses a given body of air, but, unlike the motor of Ericsson, the alternate heating and cooling are done in separate cylinders. The air is heated in the cylinder B and cooled in the cylinder A. The plunger C fits the cylinder A in its upper portion, but is contracted in the lower part to allow of an annular space between it and the wall of the cylinder. The power-piston D also fits its cylinder B tightly in the upper portion, but loosely in the lower heated part. A leather packing, K K, in each cylinder secures as in other engines a perfect fit of these moving parts. Between the two cylinders is placed a regenerator, H, consisting of a number of perforated plates, through which the air passes in going from one cylinder to the other. Around the lower portion of the cylinder B is a water-jacket, E, and encircling the same part of the heating cylinder B is a metal shell, F, curved inward at the base. The extension G of the cylinder B down into this shell forms a narrow annular space, through which the air entering the heater has to pass in a thin sheet, and thus becomes thoroughly heated. In action, the plunger C descends and compresses the air below it to one third its previous bulk ; then by the further upward movement of the power-piston D and the completion of the down-stroke of the plunger, this air is transferred to the heater. This compressed air becoming heated expands and forces the power-piston to the end of its stroke, and entering the cylinder A carries the plunger

nearly to its extreme upper position. The air in contact with the water-jacket becoming cooled contracts, and the pressure is reduced below the power-piston, which then descends by the force of the atmosphere. As it reaches the end of its downward stroke and begins

Fig. 10.



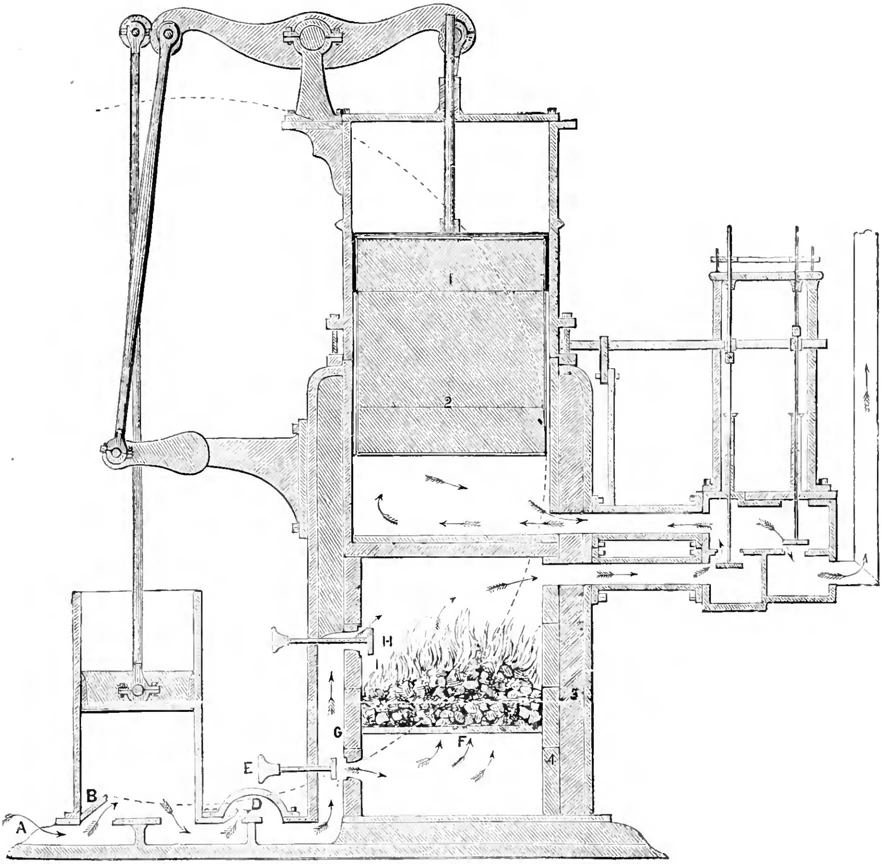
to ascend, the plunger comes down and the operation is repeated. When the air passes from the heater to the cool cylinder A, it heats the plates of the regenerator and this heat is given off to the cool air, when it is again forced into the heater. The utmost of the heat is thus utilized that is possible. The start in this as in all hot-air and gas

engines must be made by hand, but after a few turns of the fly-wheel the motion acquired is maintained by the engine.

The engine is supplied with either a deep well-pump, or one for use when the water is not more than twenty or twenty-five feet below it. The former is a simple contrivance, tubular in form, so that it can readily be inserted in artesian wells. The pump for use with water at less depths is of special construction, provided with rolling valves. It is bolted to the cooling cylinder, and worked directly from the compression piston or plunger. With one or the other of these pumps the motors can be adapted to every variety of circumstance in which water is to be drawn from one point and conveyed to another. Houses in the country can have as complete a water-supply, and have it in as convenient a shape, as those in the city, and at but little greater cost.

One of the best of this class of motors made for power purposes is the Sherrill-Roper engine, shown in section in Fig. 11. The manner

FIG. 11.



of using the heated air in moving the piston differs somewhat from that employed in the engines above described, being more nearly like that in which steam is used in the steam-engine. The furnace is air-tight, the air drawn from the atmosphere being forced through and over the fire, and the expanded air and products of combustion being admitted to the cylinder through valves worked by the engine in a way entirely similar to the admission of steam in the steam-engine. The cylinder is placed over the furnace, from which it is separated by a partition of iron faced with fire-brick upon the furnace-side. This furnace is lined with fire-brick upon all sides except the bottom, making a very durable construction, as there is nothing exposed to the direct action of the fire, to burn out. The air is drawn from the atmosphere by the upward movement of the piston in the small cylinder at the left, through the valve B, and on the down-stroke of this piston is forced through the channel G into the furnace. The valves H and E regulate the amount passed over and through the fire. The heated air and products of combustion are admitted into and exhausted from the cylinder through the puppet-valves, shown in the chamber to the right of the engine. A steady gradually diminishing pressure is exerted against the piston by these heated gases, and drive it to the upper end of the cylinder. The exhaust-valve then being opened by the mechanism of the engine, the piston descends by atmospheric pressure, forcing the gases out into the air. While the power-piston is making its downward stroke the supply-piston draws in a fresh charge of air, which is forced into the furnace during the up-stroke. A fly-wheel makes the motion of the engine smooth and uniform. The power-piston consists of two shells, the upper one turned true to fit the bored portion of the cylinder, and the lower one fitting it loosely. This latter protects the first portion from direct contact with the heated gases, and, as the upper part of the cylinder does not become overheated, a water-jacket is not needed. As the furnace is a closed compartment, the engine must be stopped in order to replenish the fire. This is not so much of an inconvenience, however, as it would at first sight appear, as one firing in the morning and another at noon, when the motor is running continuously ten hours a day, are all that are required. The machine is compactly built, and runs with very little noise. It is made in sizes of from one and a half to seven horse-power, at prices ranging from something less than five hundred to one thousand dollars. According to the statement of the manufacturers, the engine is exceedingly economical of fuel, the one-and-a-half horse-power using but forty pounds of coal per day of ten hours, and the three-and-a-half, eighty pounds. This is but a little over two pounds per horse-power per hour, a result attained in the steam-engine only in the larger-sized and most perfectly constructed machines.

THE ADVANTAGES OF IGNORANCE.

By Professor F. W. CLARKE.

THE occasional blissfulness of ignorance has long been the subject of one of our most popular proverbs. Coupled with a positive statement as to the folly of wisdom, it passes from mouth to mouth with the authority of an oracle. But the support given to the dogma is usually of a passive kind. The doctrine is stated, but not defended; while on the other hand our journals teem with arguments in favor of education, upon the importance of schools, and about the best methods of electing school trustees. The fact that the latter represent in their own persons the advantages of ignorance—that educated men can rarely attain to such superior positions—is never urged with anything like proper vigor. Education in one's self imbues one with prejudices concerning the education of others; and such prejudices, with their attendant partialities, ought to be rigidly excluded from the management of public institutions. Accordingly, in actual practice, uneducated men are placed as supervisors above thousands of cultivated teachers; and thus, in spite of the schools, the superiority of ignorance is clearly demonstrated.

In every walk of life, in all professions, a similar superiority is daily manifest. At the polls, the trained and intelligent statesman is defeated by the loud-mouthed stump-speaker, who knows nothing of jurisprudence, less of political economy, and only enough of finance to be able to draw and spend his salary with commendable regularity. The broadly educated, highly cultivated theologian is surpassed in popular esteem by the swaggering revivalist, who tears up human feelings by the roots as a child pulls up sprouting beans for growing the wrong way. In medicine, the quack has five times the patronage of the well-informed physician, and makes a fat living where the latter would only starve. Sick people are fond of liberal treatment, and like to be thought worse off than they really are. You have a slight cold, and a good doctor charges five dollars for curing you. But the brilliant empiric calls it congestion of the lungs, diphtheria, or pneumonia, visits you twice as often, and charges three times as much, and you feel that you have got a great deal more for your money. Your own ignorance chimes in with his, and both are better satisfied. Your stomach-ache is magnified into gastric fever; your boil becomes an incipient cancer; a slight chill indicates approaching typhoid. The quack flatters your self-love, exalts your own importance in exaggerating that of your disease, comforts you with a good, sympathetic scare, and depletes your veins and your pockets with admirable equanimity.

The old saying that "fools rush in where angels fear to tread"

affords another argument in behalf of the fools. To be sure, the natural history of the angel species has been but imperfectly studied; yet here again our very ignorance helps us. Theoretically, we should all like to be angels; but, practically, we prefer to stay where we are. Besides, familiarity with angels might be exceedingly uncomfortable; especially if they should take it into the ghosts of their late heads to visit us in spook-fashion, with the accompaniments of blue-fire and winding-sheets. But to the point again. Education makes men cautious and calculating; careful of precedents; afraid of mistakes. Many a time the brilliant audacity of a daring ignoramus has achieved successes which would have been unattainable to orderly skill and training. Lord Timothy Dexter, that most inspired of idiots, sent a cargo of warming-pans to the West Indies. The natives took the bottoms for sugar-scoops and the perforated lids for strainers, and Dexter gained a fortune out of his ridiculous venture. Zachary Taylor, whipped by a Mexican army, was too bad a soldier to be conscious of his defeat, and kept on fighting. His adversaries, astonished at his perseverance, thought he must have hidden reserves, and incontinently ran away. Thus Taylor won the battle, as contemporaries say, "by sheer pluck and awkwardness." "Against stupidity the gods themselves fight powerless." Stupidity, therefore, by all the rules of logic, must be superior to sense, and truly deserves, over all competitors, the crown of laurel.

The advantages of ignorance may be further illustrated by a reference to the disadvantages of omniscience. Suppose one of us could know everything, past, present, and future—how uncomfortable he would be! Looking backward into remote antiquity, he would behold his ancestral ape engaged in the undignified performance of catching fleas. Turning with disgust from the past, he would find in the present many things as humiliating. Misunderstandings, bickerings, hatreds, and slanders, unknown to ordinary men, would stand revealed before him. And from the coming time he would anticipate trouble and misfortune; he would see approaching evils far off in the dim distance; and not even the knowledge of attendant pleasures could quite unsadden him. To know everything would be to learn nothing—to have no hopes and no desires, since both would become equally futile. After the first excitement, one would harden into a mere automaton—an omniscient machine—with consciousness worthless, and volition a farce. Had Shakespeare been able to foresee his commentators, his greatest works would never have been written.

There are two sides to every question. Like the god Janus, all things are double-faced. Knowledge is not unalloyed good; neither is ignorance unadulterated evil. If ignorance were abolished, how many teachers would starve for want of occupation! Were all fools to become sensible, what would the knaves do for a living? The ignoramus, so long as he is ignorant of his ignorance, is comfortable and

self-satisfied. The educated man sees how slender his attainments really are, and discontentedly strives for deeper knowledge. Let us be impartial, whether we praise, blame, or satirize. Blessed be stupidity, for it shall not be conscious of its own deficiencies.

ÆSTHETIC EVOLUTION IN MAN.

By Professor GRANT ALLEN.

ALL the higher processes of evolution are necessarily so complex in character that we can really deal with only a single aspect at a time. Hence, in spite of the rather general title which this paper bears, it proposes to treat of æsthetic evolution in man under one such aspect only—that of its gradual decentralization, its increase in disinterestedness from the simple and narrow feelings of the savage or the child to the full and expansive æsthetic catholicity of the cultivated adult. We have to trace the progress of the sense of beauty from its first starting-point in the primitive sensibilities of the race or the individual to its highest development in the most refined and advanced of European artists.

To do so, we must first find this starting-point itself. What is the center from which the widening circle of æsthetic sensibility takes its departure? In other words, what is the primitive source of the appreciation of beauty? Putting the question into a concrete form, what objects did man, as a whole, and does each man in particular, first find beautiful? If we look at a cultivated European, we see that he derives great æsthetic enjoyment from contemplating the sunset clouds, the green trees, the lakes, rivers, and waterfalls, the flowers, birds, and insects around him. But, if we look at a savage or a child, we see that for the most part they care for none of these things. We might almost conclude, on a hurried glance, that they had no sense of beauty whatsoever. Yet, when we examine them a little more closely, we find that there are many objects to which they do apply some such word as *pretty*, the symbol of the simplest æsthetic appreciation. If we can discover the limitations of these earliest æsthetic objects, we shall have solved one of the most important fundamental problems in the theory of beauty.

The settlement of such fundamental problems seems to me an indispensable preliminary to the construction of a scientific doctrine of æsthetics. When professors of fine art discuss the principles of beauty, they are too fond of confining themselves to the very highest feelings of the most cultivated classes in the most civilized nations. The mere childish love of colors, the mere savage taste for bone necklets and carved calabashes, seem beneath their exalted notice. Nay, more, we constantly find them accusing one another of having no feeling for beauty,

or at least very little. Thus we see Mr. Ruskin and Mr. Poynter each mutually denying the other's powers of appreciation. But the psychological æsthetician can not confine his attention to such exceptional and highest developments of the love for beauty as engage the whole interest of these artistic critics. He must look rather to those simpler and more universal feelings which are common to all the race, and which form the groundwork for every higher mode of æsthetic sensibility. It is enough for him that all village children call a daisy or a primrose pretty: he need not go far afield to discuss the peculiar specific merits of a Botticelli or a Pinturiccio. Hundreds of thousands, who would stare in blank unconcern at a torso from the chisel of Phidias, can love and admire "the meanest flower that blows," with something not wholly unlike the welling emotions of a Wordsworth. Indeed, one is often inclined to fancy that the truest lovers of beauty in nature, or in the works of man, are not always those who can talk most glibly the technical dialect of art-criticism.

If we wish to hit upon the primitive germ of æsthetic sensibility in man, we can not begin better than by looking at its foreshadowing in the lower animals. There are two modes of æsthetic feeling which seem to exist among vertebrates and insects at least: the first is the sense of *visual beauty* in form, color, or brilliancy; the second is the sense of *auditory beauty* in musical or rhythmical sound. The former of the two modes I have endeavored in part to illustrate in my little work "The Color-Sense": the latter has been admirably treated by Mr. Sully in his valuable essay on "Animal Music," which appeared in the "Cornhill Magazine" for November, 1879. Now, if we look at the manner in which insects, birds, and mammals apparently manifest these presumed æsthetic feelings, we shall see that they are very restricted and limited in range. Animals never seem to admire scenery, or foliage, or beautiful creatures of other species. They do not appear for the most part to care greatly for human music, or for any sounds other than those uttered by their own kind. They do not even show any marked æsthetic enjoyment of the lovely flowers and fruits whose tints, as Mr. Darwin teaches us, are mainly due to their own selective action. But, if our great biologist is correct in his reasonings,* they

* I should like to add parenthetically that, since the appearance of my work "The Color-Sense" and the numerous criticisms to which it gave rise, I have fully reconsidered the whole question of sexual selection in the light of all that has been written about it, and feel only the more convinced of the general truth of Mr. Darwin's views upon the subject. It may be naturally objected that I am not an impartial witness in this matter: but I should like further to state that, on examining the various authorities, *pro* and *con*, I find in every case that the persons who are uncommitted to any special theological, quasi-theological, or metaphysical theory of evolution agree in full with Mr. Darwin, while only those differ from him who are bound down, *en parti pris*, to some more or less supernatural view of evolution, like Mr. Wallace, Professor Mivart, and Mr. J. J. Murphy, and who are therefore averse to any naturalistic explanation of the sense of beauty. I hope hereafter and elsewhere to enter more fully into this important question.

do very distinctly display their admiration for the beautiful forms, colors, and songs of their own highly decorated or musical mates. The facts on which Mr. Darwin bases his theory of sexual selection thus become of the first importance for the æsthetic philosopher, because they are really the only solid evidence for the existence of a love for beauty in the infra-human world. Granting the truth of his views (on which I for one have no shadow of doubt now remaining), we have good proof of a taste for symmetry and curved form in the magnificent tail of the lyre-bird, in the wedding plumage of the whydah-bird, in the twisted horns of the kudu antelope ; of a taste for color and luster in the gorgeous train of the peacock, in the metallic necklets of the humming-bird, in the exquisite wings of tropical butterflies, in the bronze and gilded armor of the rose-chafers ; lastly, of a taste for musical sound in the stridulation of the cicada and the house-cricket, in the deep notes of the bell-bird and the howler monkey, in the outpoured song of the linnet, the sky-lark, and the nightingale.

This close restriction of the æsthetic feeling to those objects which most nearly concern the individual, and through him the species, is only what we should naturally expect among the lower animals. We could hardly fancy them interesting themselves in anything so remote from their own personal wants as the rainbow or the sunset, the blue hills and the belted sea. They and their ancestors before them could not have gained any advantage by turning aside their attention from the practical pursuit of food or mates, to the otiose contemplation of that which profiteth nothing. Our own disinterested love for things so distant from our substantial needs has arisen gradually through a long process of ever-widening sympathies and ever-multiplying associations. But two things the insect, the bird, or the mammal could notice, and gain an advantage for itself or its race by noticing. It could pick out by its eye the forms and colors of edible foodstuffs among the unedible and relatively useless mass of foliage upon earth—the red berry or blossom from the green leaves, the fat white grub from the brown soil, the lurking caterpillar from the stalk whose lines and hues it so exactly imitates. It could distinguish by its ear the chirp of the savory grasshopper from the click of the hard or bitter beetle, the pretty note of the harmless sparrow from the deep cry of the dangerous hawk or the greedy jay. Thus eye and ear alike became educated among the superior articulates and vertebrates, in anticipation, as it were, of their higher æsthetic functions.

In the choice of mates, however, the powers so gained were exercised in a way which we can not consider as falling short of the true æsthetic level. Even the lowest animals (among those in which the sexes are different) seem instinctively to distinguish their fellows from all other species. In the higher classes, where the eye and ear have been so educated as to discriminate minutely between various forms, colors, shades, and notes, the instinct must almost certainly operate

through the senses of sight and hearing. Even among those races of insects, birds, and mammals in which no distinct marks of sexual selection exist, I believe the sight of beautiful members of their own kind must necessarily excite pleasurable feelings worthy of being ranked in the æsthetic class. In other words, I believe every crow must think its own mate *beautiful*—not merely inferentially pleasant, but in the truest sense beautiful. There must be, it seems to me, such an intimate correspondence between the needs and the tastes of each species, that the sight and voice of a healthy, normal, well-formed mate must have become intrinsically pleasing for its own sake, as well as indirectly for its associations. The nervous centers of each species must, I conceive, be so constructed hereditarily as to answer congenitally to certain typical shapes and sounds often experienced ancestrally, and always with ultimate benefit to the race. Though the emotions require experience of the object to arouse them, when the object occurs the emotions naturally arise. Just as man has special cerebral structures—existing, though dormant, even in deaf-mutes—for the perception and production of human language, so, I can not but believe, every species of higher animal has special cerebral structures, with special corresponding blank forms of perception, for the intellectual recognition and appropriate emotional reception of its fellows and its mates. These feelings are innate in the sense that they occur spontaneously at sight of the proper objects. When Miranda falls in love at first sight with Ferdinand, the only young man she has ever seen, it seems to me that the poet has truly depicted a genuine psychological fact. At any rate, it is indubitable that, so far as man is concerned, the human voice has certain points of emotional and technical superiority over every other kind of musical instrument, and that the beauty of woman and of the human form is now and must always remain the central standard of beauty for all humanity.

The heart and core of such a fixed hereditary taste for each species must consist in the appreciation of the pure and healthy typical specific form. The ugly for every kind, in its own eyes, must always be (in the main) the deformed, the aberrant, the weakly, the unnatural, the impotent. The beautiful for every kind must similarly be (in the main) the healthy, the normal, the strong, the perfect, and the parentally sound.* Were it ever otherwise—did any race or kind ever habitually prefer the morbid to the sound, that race or kind must be on the high-road to extinction. The more every individual shares the healthiest tastes of its kind, and puts them in practice in the choice of a mate, the more is he or she insuring for descendants a healthy and a successful life whereby it hands on its own sound taste to future gen-

* This doctrine has been admirably illustrated by Mr. Herbert Spencer so far as regards the human species, in his essay on "Personal Beauty," which, though published long before the appearance of the "Descent of Man," really contains the germ of the doctrine of sexual selection.

erations. But, besides this fundamental typical beauty—the beauty which consists in full realization of the normal specific form—there is another source of personal beauty on which sexual selection may act, and through which it has produced the greater number of its most striking effects. This source may be found in the exercise of tastes otherwise acquired upon relatively unimportant details of form, color, or musical abilities. The taste for bright hues, acquired through the search for food in blossoms, berries, or brilliant insects, may be transferred to the search for mates, so that those mates will be most preferred which happen to vary most from the original typical coloration in the direction of more brilliant hues. The taste for musical sound, implied, as I have elsewhere tried to show on the lines laid down by Helmholtz, in the very structure of the auditory apparatus (at least in birds and mammals), may be exercised in the preference given among birds to the sweetest or the loudest singers. Unimportant ornamental points may thus be constantly developed by continual selection of small gradations, when they do not interfere with the general efficiency of the organism, till at length we get such highly evolved æsthetic products as the waving plumage of the bird-of-paradise, the sculptured antlers of the gazelle, and the varied song of the mocking-bird. And since, as Mr. Wallace has shown (he himself believes in opposition to, but I rather fancy in confirmation of, Mr. Darwin's theory), these ornamental adjuncts or faculties are most likely to coexist with the highest sexual efficiency, it must happen that in the main sexual selection and natural selection will reënforce one another, the strongest and best being always on an average the most beautiful, and hence the most pleasing to all possible mates.

In this way, I take it, a sense of beauty in the contemplation of their own mates must have grown up among all the higher animals, and must have became strongest and most discriminative among those whose mates have undergone the greatest amount of ornamental differentiation. And as the secondary differences between man and woman as to beard, hair, and features, are greater than between the two sexes of almost any other quadrumanous animal, we may conclude that man's æsthetic appreciation of beauty in his own species has always been very considerable. Of this æsthetic appreciation, the secondary differences in question are at once the proof, the cause, and the effect. For, in the constant action and reaction of heredity and adaptation, it must happen that the greater the original taste, the more will it be exerted in the choice of mates; and, the more it is exerted in each generation, the greater will be its effects, and the more will the taste be strengthened in all future generations.

This, then, would seem to be the primitive starting-point of which we are in search. Man in his earliest human condition, as he first evolved from the undifferentiated anthropoidal stage, must have possessed certain vague elements of æsthetic feeling: but they can have

been exerted or risen into conscious prominence only, it would seem, in the relation of primeval courtship and wedlock. He must have been already endowed with a sense of beauty in form and symmetry, a sense which, in spite of its wide expansion and generalization in subsequent ages, still attaches itself above every other object, even with Hellenic or modern sculptors, to the human face and figure. He must also have been sensible to the beauty of color and luster, rendered faintly conscious in the case of flowers, fruits, and feathers, but probably attaining its fullest measure only in the eyes, hair, teeth, lips, and glossy black complexion of his early mates. And he must have been moved, as Mr. Darwin argues, by musical tones and combinations, though chiefly in the form of human song or rhythm alone. In short, the primitive human conception of beauty must, I believe, have been purely *anthropinistic*—must have gathered mainly around the personality of man or woman; and all its subsequent history must be that of an *apanthropinization* (I apologize for the ugly but convenient word), a gradual regression or concentric widening of æsthetic feeling around this fixed point which remains to the very last its natural center. By the common consent of poets, painters, sculptors, and the world at large, the standard of beauty for mankind is still to be found in the features and figure of a lovely woman.

Probably primitive man admired his pre-glacial Phyllis or Neæra, admired himself, and perhaps also admired his fellow-man. So far as I can learn, there are no savages so low that they do not discriminate between pretty squaws or gins and plain ones, between handsome men and ugly ones. Our own children appear to me to make the distinction among their playmates from a very early age. And, in both cases, I am satisfied that their judgment in the main agrees with our own.* But it does not seem likely that primitive man took much notice of scenery, of organic beauty as a whole, or even very largely of beauty in flowers, berries, butterflies, and shells. Yet there was an obvious link, a simple stepping-stone, by which nascent æsthetic feeling might easily pass from the one stage to the other. That link is given us in the love for personal decoration.

Not only does every unsophisticated man wish to find a pretty mate, but he also wishes to look to advantage in her eyes and those of his rivals. Similarly, every woman wishes to look pleasing toward all men. The most naked savages take immense pains with their fantastic coiffures. Even birds display their beauty to the best advantage, and sing in emulation with one another till their strength fails them. But birds and mammals generally go no further than this: man can take one step in advance, and add to his natural beauty, or conceal his

* I noticed in Jamaica that the negroes generally considered as pretty negresses the same women as we should ourselves have selected among them; and many persons who have traveled among various savage races, and whom I have had an opportunity of questioning, confirm this general conclusion.

natural defects, by borrowed plumes. So the earliest evidence of derivative æsthetic feeling which we possess is that of the personal ornaments worn by palæolithic men. Perforated shells, apparently used for necklaces; teeth of deer and other animals; pebbles of rose-quartz and other ornamental stones; wrought pieces of bone or mammoth-ivory—all of them obviously intended for personal decoration—are found in the earliest cave-dwellings and rock-shelters. Feathers and flowers we can not of course expect to find in such situations; but we can hardly doubt, from the analogy of almost all modern savages, that palæolithic men must have used them as much as they used those other decorative objects. Now, the fact that any such shells or plumes are sought as ornaments proves of course that they were first admired; but the vague admiration originally bestowed upon them would naturally be much quickened and increased by their employment for the decoration of the person. From being vague and indefinite it would become vivid and purposive. Our own children and modern savages take comparatively little interest in flowers in the abstract, flowers as they grow upon the bush or in the field: but they begin to admire them when they pick them by handfuls, and still more when they are woven into a wreath, arranged in a bouquet, or stuck into the hair. Nay, is not this ultimate decorative intent one of the chief *raisons d'être* for many of our European conservatories and florists' shops? Is not a camellia largely admired because it looks so well in a ball-dress, and a stephanotis because it fits so easily in a button-hole? And is it not a fact that many of our ladies and most of our servants admire artificial flowers, with all their stiffness and vulgarity, far more genuinely than they admire living roses or lilies-of-the-valley? We have all known women whose most real æsthetic feelings were obviously aroused by a bonnet or a head-dress.

Flowers are very favorite decorations with the South-Sea Islanders, and those who have read Miss Bird's and Mrs. Brassey's pleasant accounts of their stay among the Polynesians must have noticed the air of refinement, the vague æsthetic atmosphere thrown over the whole story by their profuse employment of tropical blossoms upon all occasions. Feathers, symmetrically arranged, were the ordinary head-dress of the North American Indians; and they were woven into splendid cloaks by the Hawaiians. Corals, pebbles, precious stones, gold and silver jewelry, cowries, wampum beads, furs, silks, and so forth, follow in due order. Ochre and woad, for dyeing or staining the body, are employed from a very early period. Henna, indigo, and other cosmetics come a little later. Among many existing lowest races, the only sign of æsthetic feeling, beyond the sense of personal beauty and the very rudest songs or dances, is shown in the employment of dyes or ornaments for the person. Such are many of the Indian Hill tribes, the Andamanese, the Digger Indians of California, and the Botocudos of Brazil. The Bushmen, and to a less extent the Australians, gen-

erally ranked in the lowest order, reach a decidedly higher æsthetic level.

In most savage communities, the men, not the women, monopolize the handsomest costumes, which are worn as marks of distinction, not merely as ornaments. But the former use must be necessarily derivative and secondary, not original. Mr. Herbert Spencer has gathered together a large and interesting collection of cases in his "Ceremonial Institutions" (chapter ix). Nevertheless, the original æsthetic intent of most of such decorations is obvious from the fact that they are universal among women, whenever they do not arise from the habit of trophy-taking, as with the use of flowers with the Polynesians generally. So, too, tattooing and other mutilative practices, originally subordinative in their intention, becoming at last merely æsthetic, are prized by women as increasing their natural attractions. Every one must remember the plea of the New Zealand girls, quoted by Mr. Darwin, who answered the remonstrances of the missionary against tattooing by saying, "We must have just a few lines upon our lips, or else when we grow old we shall be so very ugly." Similarly, Central African women admire their own *pelelé*, the piece of wood inserted in their mutilated lips. I notice in many works of travel that, even where the men almost or entirely monopolize the ornaments, the women are always described as displaying great admiration for the beads, red cloth, and other finery taken about by travelers. I may add that I am often struck by the extraordinary folly of missionaries, who habitually preach down the love of ornament on the part of savages or of emancipated slaves (especially the women), when in reality this love is the first step in æsthetic progress, and the one possible civilizing element in their otherwise purely animal lives.* It ought rather to be used as a lever, by first making them take a pride in their dress, and then passing on the feeling so acquired to their children, their huts, their gardens, and their other belongings.

Such in fact has been, I believe, the actual course of our æsthetic evolution. The feelings vaguely aroused by beautiful objects in the non-practical environment become whetted and strengthened by exercise upon ornaments and pigments, and so extend themselves with increased vividness into new channels. Art, however rude, has especially helped on this primitive progress. The appreciation for the beautiful in man's handicraft leads on to the appreciation of the corresponding beauty in natural objects. I have attempted to trace this reaction, so far as regards the sense of symmetry, in a previous number of this journal,† and I shall endeavor still further in the

* I once asked a West Indian official of great experience and liberal views whether, in his opinion, Christianity had done any practical good to the negroes; and I was much struck by his answering: "Oh, yes! It makes them dress up in good clothes once a week, and so gives them an object in life for which to work and save."

† See an article on "The Origin of the Sense of Symmetry," in "Mind," xv.

present paper to illustrate its progress in a somewhat different direction.

From delight in the beauty of ornaments to delight in the beauty of weapons or other utensils is but a step. What a man carries in his hands is almost as much a matter for personal pride as what he wears around his neck or his waist. From the very earliest ages, the material for palæolithic stone hatchets seems to have been intentionally chosen with conscious reference to beauty of color. Among the minerals so employed were "red or other colored jasper"; "greenstone, mottled jade, and green jasper"; "quartz, agate, flint, obsidian, fibrolite, chloromelanite, aphanite, diorite, saussurite, and staurotide." The bone knife-handles and other utensils from the rock-shelters of the Dordogne (of palæolithic date) are admirably carved into the forms of animals, or decorated with ornamental patterns. Indeed, both in outline and detail, most works of art of the chipped-flint period show very distinct æsthetic care, which is often marvelous when one considers the extremely rude nature of the tools in use, and the immense extra labor entailed upon the maker by any attempt at unnecessary ornamentation. The weapons of all but the very lowest existing savages show similar marks of æsthetic care. Their stone hatchets, besides being exquisitely polished, like those of the European neolithic age, are fitted in smooth wooden handles, and bound to the shaft by pretty twisted strings of red and yellow fiber. The Australian boomerangs are beautifully worked in hard wood. The staves or clubs of the Admiralty Island chiefs are wrought with the most exquisite and laborious tracery, which puts to shame our careless European wood-carving. The canoe-paddles of other Polynesian and Melanesian tribes are models of graceful and effective ornamentation. Among many savages belonging to the second rank, I find few works of art except weapons or like personal utensils on which any high degree of pains has been expended. We may therefore fairly regard this as the second human stage of æsthetic development.

Hardly superior to this second level is the love for decoration on vessels and other domestic utensils. Yet these, as being just one degree less personal than weapons, may be regarded as occupying a slightly higher stage. Calabashes and cocoanuts are almost always carved or decorated. Pottery from the very first is more or less ornamental in form, and even among very undeveloped savages is often prettily molded with lines or string-courses. Many of Dr. Schweinfurth's Central African specimens are extremely graceful; while several of the exquisitely simple prehistoric forms unearthed by Dr. Schliemann at Troy and Mycenæ have been adopted as effective models for the modern artistic Vallauris ware. France itself can produce nothing more beautiful in its own kind.

Decoration of the home is one degree more disinterested than decoration of the person or personal implements. The palæolithic savages

who carved the knife-handles and etched the pictures of reindeer or mammoths, in southwestern France, still lived in caves and holes of the rock. But as soon as man began to dwell in a hut, that hut began to take the impress of his growing æsthetic tastes. Swiss lake-dwellings present regular square or circular ground-plans. Esquimau snow-houses are finished with as much regularity and neatness as if they were built in the most durable material. Almost all savage huts are picturesque in shape, and some are even artistic in their simple style of architecture. The rudest tribes care for little but the exterior of their dwellings, since the interior is only used as a shelter for sleeping or a retreat from wet weather, not as a place of reception. Pride in personal possessions, we must always remember, has uniformly formed the stepping-stone on which our nature has slowly risen to a higher æsthetic level. So, we find houses beginning to be ornamented internally just in proportion as they are used for purposes of display. Even our own homes usually have the drawing- and dining-rooms much more elaborately decorated and furnished than the other parts of the house. The state-apartments of halls and palaces contain all the best pictures and the handsomest mosaic tables that their owners possess.

At this stage, the governmental and ecclesiastical impetus begins to be strongly felt. From the very beginning, indeed, æsthetic products are specially the attributes of royalty and divinity. The clubs and paddles noted above are those of chiefs alone: the Hawaiian feather mantles were *taboo* to the royal family: the ivory scepter and the vermilion-painted face "belonged alike to the Roman god and to the Roman king." But, when we reach a state of culture at which the royal palace and the temple are widely different from the huts of the subject, we find a great æsthetic advance. Architecture is indeed a specially regal and religious art. All early buildings of any pretensions are either palaces or shrines: only at a comparatively late stage of evolution, and under an industrial *régime*, do handsome mansions of commoners begin to exist. Even in our own day, if we see an exceptionally large and pretentious house, we take it for granted that it is, if not a palace, at least a public building. In India, all the great architectural works are either mosques and temples or palaces and mausoleums of native or foreign rulers. In Egypt, they are either pyramids of dead kings or fanes of still earlier gods. So, too, in Mexico, Peru, Central America. The catalogue of the works of art in Solomon's temple and Solomon's house, whether authentic or not (and good authorities accept it as historical), represents at any rate the æsthetic status of the Hebrews at the date at which it was committed to writing.

The king, then, from the first surrounds himself with such natural or artistic products as add to his impressiveness and dignity. Trophies and other decorations of warlike origin, badges and costumes, paint and ointment, have been so fully treated in this connection by Mr.

Herbert Spencer in his "Ceremonial Institutions" that I need not dwell upon them further here. But a few words as to later and more developed stages may not be out of place. Architecture is the central royal art, and its first object is to "beautify the house of the king." Beginning with the regal hut, it goes on to the frail and gilded palaces of China and Burmah, the house of cedar which King Solomon builded, the vast piles of brick erected by Assyrians and Babylonians in the alluvial valley of the Euphrates, the solid granite colonnades of Thebes and Memphis, the huge marble domes of Agra and Delhi, the stucco monstrosities of Mohammedan Lucknow. Sculpture first grows up as the handmaid of architecture, and begins its modern form with the bas-reliefs of Egypt and Assyria, or the rock-hewn colossi of Elephanta. We still see the conjunction between royalty and these two sister arts in the beautiful Renaissance façade of the Louvre and the tasteless gilding of the Albert Memorial. Beside the ancient Nile or in the courtyards of Nineveh, we find the subjects ever the same—the king conquering his enemies; the king hunting and slaying a lion; the king driving a herd of naked captives to his capital city. Thus the aggrandizement of royalty becomes at the same time the opportunity for the exercise and development of plastic skill, while it affords models of the beautiful in art for the admiration and the æsthetic education of the subject throng.

Similarly with painting. Beginning with the rude decoration of the savage cloak and girdle, it advances to the smearing and gilding of the royal hut. Thence it progresses to the brilliant coloration of Egyptian columns and frescoes, and to all the Memphian wealth of blue, green, crimson, and gold with which so many modern restorations have made us familiar. In India, debarred from imitation by Moslem restrictions, it produces the exquisite decoration of the Taj and the Delhi palaces: in western Islam, it gives us the gorgeous Moresque tracery of the Alhambra. In its regular European development, becoming mainly ecclesiastical during the early middle ages, it reasserts its original governmental connection in the palaces of Florence and Venice, in the Vatican, in the Louvre and the Luxembourg, in Whitehall and Hampton Court, in Dresden and Munich, in modern Berlin and St. Petersburg. Sèvres and Gobelins were originally royal factories: Giotto, Michael Angelo, Raphael, Holbein, Rubens, Vandyke, all produced their masterpieces for popes or kings—Leo X, Henri IV, Charles I. Conversely, American artists have often noted the chilling effect of the want of a court upon the æsthetic susceptibilities and creativeness of their countrymen generally. Europe has, on the whole, purchased its art at the hard price of its long apprenticeship to despotism. In India, native art has steadily died out with the gradual extinction of the native courts. In Hellas and Italy it happily survived royalty because pressed into the double service of religion and of the sovereign people in its corporate capacity. What the

house of Pharaoh was to Egypt, that was the house of Athene to Athens.

The gods, indeed, have done almost more for the expansion of the æsthetic faculty than even the kings. If the savage decorates the living chief and his house, how much more must he decorate and beautify the image and the house of that greater dead chief, the god—that ancestral ghost whom even the living chief dreads and venerates exceedingly! Hence, from the very first, while the ornaments of the king and the god are the same in kind, those of the god are the finest in degree. As the ghost gradually expands into the vaguer grandeur of the deity, his worship is surrounded with increasing magnificence. It is the temples of Heliopolis and Benares which naturally occur to our minds when we think of Egyptian or Indian architecture. It is the pyramids and mausoleums that form the initial stage of ecclesiastical buildings. All the world over, the shrines of the gods are the most splendid of all erections: only where faith is on the decline do we find the palace or the mansion outvying the cathedral and the chapel. In architecture, in sculpture, in painting, in music, the homes of the gods are the highest expression of national æsthetic feeling. Passing from the painted pillars of Karnak to the temples of Khorsabad and the mosques of Agra, we find the same care everywhere bestowed upon the service of the deities. In Hellas, we have the Parthenon and the Theseum; we have the chryselephantine statues of Phidias, and the votive tablets of Praxiteles. The marbles of Pentelicus or Paros permitted the Hellenic Aphrodite to assume a graceful and natural pose, which would have been impossible with the stiff granite limbs of a Pasht carved out from the quarries of Syene. At Rome, we have the Capitoline Jove, yielding place at last to the palace of the Divus Cæsar and to the basilica of the Christian apostle. All classical architecture, all classical sculpture, the larger part of classical painting, and no small part of classical poetry, are directly due to the influence of the old Helleno-Italian religions. And whatever little information we can gather of the æsthetic status of the Hebrews is to be derived from the story of the hangings and vessels of the tabernacle, and the molten sea, the pillars, the bases, the lavers, and the cedar ceiling of Solomon's temple. Hebrew poetry is almost without exception devotional.

In Christian times, the connection between art and religion has been even more noticeable. Our music is directly affiliated upon the Gregorian chant, and derives its notation from ecclesiastical usages. Masses and oratorios still compose its masterpieces. Our painting has come down to us from Byzantine and early Italian models, and found its home during the whole mediæval period in the great cathedrals and churches of Italy, whence it spread to the palaces of the Florentine Medici, of the Venetian doges, and of the Genoese merchant princes, and so ultimately to northwestern Europe. The whole character of

pictorial art up to the Renaissance was entirely ecclesiastical and devotional. We have fed and nursed our taste upon Madonnas and Holy Families, upon Crucifixions and Assumptions, upon St. Sebastians, St. Johns, and St. Cecilias. Our architecture is based upon the Romanesque Christian church, whose rounded forms melt into the pointed arches of the Gothic cathedral. It finds its noblest expression in Pisa and Poitiers, Milan and Venice, Cologne and Chartres, Lincoln and Salisbury. And, when the classical revival comes to restore the older schools, it produces the masterpiece of its newer style in the vast dome of St. Peter's, where the four chief arts, architecture and sculpture, painting and music, all alike find their chosen home in the central point and focus of Catholic Christendom.

Nor is it only in these more notable forms that royalty and religion influence æsthetic taste. The purple and fine linen of kings' palaces; the inlaid cabinets and parquetry floors; the jade vases and painted porcelain; the Dresden statuettes and bronze candelabra; the frescoed ceiling, tapestry wall-covers, and carved wood-work—all these belong to the royal home. Even in poetry, the Queen still keeps her laureate; and the drama, originally a sort of royal specialty, is still performed at Drury Lane by "her Majesty's servants." Similarly with religion: the stained-glass window and the marble or mosaic altar; the costly vestments and sweet-perfumed incense; the fretted roof and the sculptured reredos—these in their turn belong to the worship of God. Such royal decorations and sacred ornaments react again upon the popular taste, both actively and passively. As an active effect, they give rise to and foster artistic workmanship: as a passive effect, they educate and strengthen the æsthetic faculties of the mass. Among the lower races, the æsthetic feelings have been closely linked with the sense of proprietorship: among the higher races, they gain more and more with every step in abstractness and remoteness from the personality of the individual. It was in the vast cathedrals of mediæval Europe that modern æsthetic feeling received its early education.

So far we have treated little of beauty in nature: beauty in art has occupied almost our whole attention. The latter prepared the human mind for the appreciation of the former. Of the manner in which the love for art passes into the love for smaller natural objects, which exhibit minute beauty of workmanship, I have already treated elsewhere: but the taste for scenery demands a few words here. Children and early races care little for nature: it is only among the most cultivated classes of the most advanced types that the æsthetic faculty reaches this its highest and most disinterested stage. All art is at first frankly anthropinistic. Early painting, such as that of the Egyptians and Assyrians, dealt only with human and animal figures: it represented men and women, kings and queens, gods and goddesses, hunters and lions, herdsmen and cattle: but it never attempted landscape or scenery.

Mediæval art in its early stages only changed its characters to saints and angels, priests and bishops. But, as it progressed from its Byzantine type, it also gradually gave more and more importance to accessories in the background, in which hills, cities, rocks, and trees, began to play a conspicuous part. At last, after the Renaissance, landscape-painting became a recognized and separate branch of pictorial art, first with an admixture of figures, wild animals, or still life, but afterward in a more fully differentiated form, with all its varieties of marine, architectural, forestine, or river subjects, its waterfalls, its clouds, its rocks, its valleys, and its heather-clad hills. Even in our own day, very young people and the uncultivated classes care little for any but figure-painting: children pass over the landscapes in their picture-books, and fasten at once upon the man on horseback or the boy with a top. The first object they try to draw for themselves is a human face. So, too, with literature. All primeval literary works consist of a legend, a story historical or mythical, the tale of what some man or some god has done. To the very end, novels, plays, and biography, the most human in their interest, are the favorite forms of literature. Poetry at first is all epic or narrative: lyric and descriptive verse only come in at a much later point of evolution, and are seldom thoroughly relished by any but the most cultivated. "Tell me a story," says the youngest child. "History is the most delightful of studies," says the Roman philosopher.

We may take the Homeric poems as an excellent illustration of human æsthetic feeling in this its naïvely anthropinistic stage. In them we find human beauty abundantly recognized and admired: Helen, for whose sake Trojans and Achaians may well contend through ten long years; Paris, on whose eyes and hair Aphrodite pours the gift of loveliness; the golden locks of Achilles, the white arms of Here, the hazel eyes of Athene, the fair cheeks of Briseis. There is much admiration, too, for works of primitive art—the golden-studded scepter, the polished silver-tipped bow of horn, the jeweled girdle of Aphrodite, the wrought figures on Achilles's shield, the embroidered pattern on the many-colored peplum which Theanô offers on the knees of Athene. The palaces of Priam and of the Phæacians excite the warmest praise of the rhapsodist. But of scenery there is little said, as is also the case in the Hebrew poets. The garden of Alcinous is, after all, but a well-ordered fruit-orchard. Nature is only alluded to as a difficulty to be overcome by man—the barren, harvestless sea; the high, impassable mountains; the forests where roam the savage wild beasts. In the Periclean age, we have a higher but still not a very exalted standard as regards natural beauty; the "Bacchæ" of Euripides being the high-water mark of Athenian love for the picturesque, and standing out in this respect as a solitary example among its contemporaries. With the greater security of Roman rule, life became less confined to the immediate neighborhood of cities; moun-

tains and forests and waterfalls became more easy to visit; and in the "Georgics" we see the result of the change. Yet even in the "Georgics" the view of nature is still very anthropinistic, and the feeling for scenery decidedly urban. What should we say of a poet nowadays who should apostrophize the beauties of an Italian lake "Fluctibus et fremitu assurgens, Benace, marino"? Would he not seem in our eyes to have missed entirely the whole spirit of the scene? The words might do for Huron or Ontario, but fancy applying them to Como or Garda! Nevertheless, the Roman mind had decidedly advanced in the love of nature. The Alps were still to Juvenal mere masses of snow barring the way from Gaul to Italy; the ocean was still to Tacitus a boundless waste of western waters; but the falls of Tivoli, the little fountain-head of Bandusia, the sweeping coast-line of Baiæ, the beetling crags of Terracina, the deep volcanic basin of the Alban lake—all these could rouse æsthetic admiration and delight in the eyes of a Horace, a Virgil, or a Claudian. With the recession of the middle ages, when men were again confined to the narrow limits of towns, æsthetic feeling went back once more to the *naïve* anthropinism of an earlier age; but, since the Renaissance, the love of scenery has grown perpetually, and it now probably reaches the farthest development that it has ever yet attained.

But we must never forget that the taste for scenery on a large scale is confined to comparatively few races, and comparatively few persons among them. Thus, to the Chinese, according to Captain Gill, in spite of their high artistic skill, "the beauties of nature have no charm, and in the most lovely scenery the houses are so placed that no enjoyment can be derived from it." The Hindoos, "though devoted to art, care but little, if at all, for landscape or natural beauty." The Russians "run through Europe with their carriage-windows shut." Even the Americans in many cases seem to care little for wild or beautiful scenery: they are more attracted by smiling landscape gardening, and, as it seems to us, flat or dull cultivation. I have heard an American just arrived in Europe go into unfeigned ecstasies over the fields and hedges in the flattest part of the Midlands.

The reason for this slow development may be briefly traced. The minor component elements of scenery must always have been to a great extent beautiful on their own account even to children and savages. Thus, the same bright color which gave attractiveness to flowers and gems must also have given it, though more vaguely, to the rainbow and the sunset clouds, which could not similarly be utilized for purposes of ornament. Color must also always have formed an element of beauty in blue sky and sea, red-sandstone cliffs, white chalk, green meadows, and golden corn-fields. All these objects, however, being comparatively remote from personal interest, would be little regarded by the primitive mind. But, when cultivation began, the care of the husbandman and the æsthetic interest aroused by his regu-

lar neatness would naturally set up a new feeling. Straight rows of vines or olives, trim meadows, well-kept hedges, level fields of corn, excite the farmer's admiration. This is about the level ordinarily reached (though often surpassed) by the "Georgics." In the "Iliad," when a place is mentioned with any allusion to scenery, it is generally because it is "fertile," "horse-feeding," or "rich in corn"; with Virgil, it is the careful tillage of Italian peasants that provokes attention. But wild hills and rocks are mere barren, good-for-nothing wastes to the agricultural eye. A few days before writing this paper I was wandering among the beautiful wooded heights of the Maurettes near Hyères, when I came across a party of peasants taking their lunch on a little plateau outside their cottage. Wishing to apologize for my intrusion, I said a few words about the singularly lovely view which their house commanded across the mountains and the sea. "Ah, yes," said one of the peasants in his Provençal *patois*, "there isn't much to see this way except the forest; but down there," pointing behind him in the opposite direction, toward the great cabbage-garden which covers the alluvial plain of Hyères—"down there one sees a magnificent country." The one view was like a bit of miniature Switzerland; the other, like a huge market-garden, as flat as this page.

Even in our own time and place, among our own race, one may see a similar æsthetic level with farmers and laborers. "So you're going to Devonshire," said a Lincolnshire yeoman to his minister (from whom I have the story); "you'll find it a poor sort of country after this. You'll never see a field of corn like ours down there, I take it." "Your country, sir," says a distinguished American visitor in England, "is very beautiful. In many parts you may go for miles together, and never see a tree except in a hedge. Nothing more beautiful can be conceived." (I take the words down from the report of an "interviewer.") To the farmer, hills like those of Devonshire were mere obstructions to ploughing: in the eyes of the practical American, trees were simply objects to be stumped and annihilated in the interest of good farming.

So long as communications are difficult and roads bad, this agricultural aspect of natural beauty will remain uppermost. It is difficult to appreciate scenery in the midst of practical discomforts. The Alps were naturally mere barriers of snow to Hannibal and Cæsar. The Scotch Highlands were less beautiful to Lowlanders when they were inhabited by hostile clansmen with a taste for cattle-lifting. Even in the last century, one is struck by the many serious discomforts which Johnson suffered in going to the Hebrides or traveling through Wales. Telford's Holyhead road must have done much to quicken the æsthetic sensibilities of the eighteenth century in England. I have myself noted in Jamaica how much the appreciation of really beautiful scenery is spoiled by the discomforts of the climate and the difficulties of transport. In such circumstances, an æsthetic feeling for scenery can hardly

develop itself. Still less could it do so during the perpetual state of siege in the middle ages, or the constant warfare of the little Hellenic republics, when no man could travel a few miles from home save on urgent business and with due precautions. A lovely pass or a frowning gorge can hardly become beautiful in the eyes of those who see in it everywhere a lurking brigand.

On the other hand, when traveling becomes easier, a taste for scenery naturally arises. All the mental elements of the taste are already present ; only their combination is wanted to complete the æsthetic growth. Tastes educated and refined by the arts of the city must find beauty ready to hand in much of the country. The garden and park, the Italian terrace and the Versailles avenues, the ornamental grounds and artificial lakes of the last century, formal as they seem to us now, show the gradual growth of the taste. A view from the castle or the hall becomes a desideratum. To look out upon fresh green fields and trees rather than upon the walls and narrow streets of a city must always have been pleasant to all but the most restrictedly anthropinistic minds—though even in our own day there are many townsmen who would find more to interest them in a crowd of people than in the loveliest scenery on earth. Again, only highly cultivated minds can thoroughly enjoy the beauty of places which have been always familiar from childhood : and we can hardly expect a taste for scenery to develop among people who necessarily live (like all but the most civilized) in one narrow place for all their days. Under such circumstances, the perception of its beauty can never arise. The habit of making tours, at first confined to the very wealthy, but gradually spreading down to the middle classes and the mass, has undoubtedly had an immense effect in strengthening the love of nature. Those who only know the stereotyped features of their own suburban fields, often flat and unlovely, can not acquire any deep interest in scenery. But when Wales and Scotland, Auvergne and Brittany, Switzerland and the Tyrol are thrown open for us all, the habit of comparing, observing, and admiring grows upon us unawares. Those railways which Mr. Ruskin so cordially despises have probably done a thousand times more for promoting a love of beauty in nature than the most eloquent word-painting that was ever penned even by his own cunning and graceful hand.

If one may trust an individual experience, it is not the first waterfall that charms the most. Niagara itself, when seen in early youth, does not produce nearly so strong an impression as the little Swallow-Fall at Bettws-y-coed in later years. The more one sees, the more one learns what to expect, what to observe, what to admire. Here it is the wind-shaken foam-streak of the Staubbach ; there, the little dancing cascades of the Giesbach ; and here again, the vast unbroken emerald-green sheet of the Horseshoe Fall, pouring in ceaseless majesty into the seething turmoil of waters at its mist-begirt feet. Each

has its own beauties of grace, prettiness, or sublimity, and each is largely apprehended and appreciated by means of half-unconscious recollections of the others. Between the American and Canadian falls at Niagara, a little belt of water forces its way through the gap which severs Goat and Luna Islands, and forms a minor cataract of its own, hardly heeded in the presence of the two great rivers plunging headlong at its side. If one fixes one's attention for a few moments on this little sheet of foam, one recognizes after a while that it is really larger than any cascade in western Europe. And, if you then turn your eyes to the vast semicircle of deep-green water on your right, you feel at once that without that standard of measurement your eye and brain would have failed adequately to grasp the mighty dimensions of Niagara.

Thus, step by step, in our own individual minds, and in the history of our race, the æsthetic faculty has slowly widened with every widening of our interests and affections. Attaching itself at first merely to the human face and figure, it has gone on to embrace the works of man's primitive art, and then the higher products of his decorative and imitative skill. Next, seizing on the likeness between human handicraft and the works of nature, envisaged as the productions of an anthropomorphic creator, it has proceeded to the admiration for the lace-work tracery of a fern or a club-moss, the sculptured surface of an ammonite, the embossed and studded covering of a sea-urchin, the delicate fluting of a tiny shell. Lastly, it has spread itself over a wider field, with the vast expansion of human interests in the last two centuries, and has learned to love all the rocks, and hills, and seas, and clouds, of earth and heaven, for their own intrinsic loveliness. So it has progressed in unbroken order from the simple admiration of human beauty, for the sake of a deeply seated organic instinct, to the admiration of abstract beauty for its own sake alone.—*Mind.*

A JAPANESE TYPHOON.

By Professor T. C. MENDENHALL.

CONSIDERABLE information has been gathered, and much has already been published, concerning the damage inflicted upon this coast and in the vicinity by the typhoon which visited us during the night of October 3d and 4th.

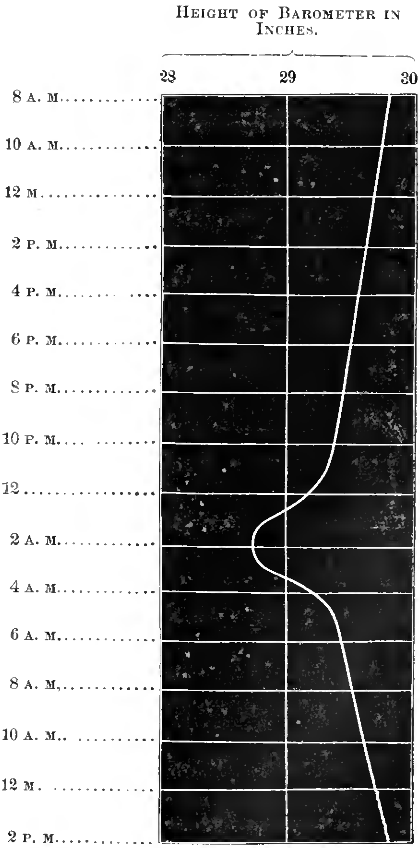
The unpleasant frequency, in this part of the world, of storms of the same character, renders their careful investigation by competent meteorologists a matter of the utmost importance. What is chiefly demanded, therefore, is the collection of such meteorological records and observations as may, perhaps, render it possible to trace completely

the rise, progress, and varying intensity of the storm. Of course, considerable time must elapse before such an investigation can be completed; and, unfortunately, even at best the number of accessible and reliable series of observations will be greatly less than could be desired for the successful study of the phenomenon.

In the mean time we deem the matter of sufficient local interest to justify a brief presentation of the principal meteorological features of the storm, based upon observations and records made at the observatory of the University of Tokio.

Although it can hardly be said that this storm gave any marked indications of its immediate approach, yet it is important to observe that

CHART SHOWING THE HEIGHT OF THE BAROMETER FROM 8 A. M. ON THE 3D TO 2 P. M. ON THE 4TH OF OCTOBER, 1880.



there was a steady fall in the barometer from the previous Thursday—September 30th—up to the time of maximum violence of the wind. The first of the accompanying charts exhibits the barometric curve

during the most interesting period; i. e., from 8 A. M., on the 3d of October, to 2 P. M. of the 4th. Previous to one o'clock on the morning of the 4th but three observations are recorded: at 7 A. M., at 2 P. M., and at 10 P. M. These indicate a steady decline in the barometer, and it is not likely that any extraordinary fluctuations occurred during this time. After 1 A. M., the observations were made hourly, and during a considerable portion of the time they were half-hourly. It will be seen, however, that a very important portion of the curve, from 10 P. M. to 1 A. M., is doubtful, and it is not at all unlikely that, had intermediate observations been recorded, the fall of the barometer would have appeared much more sudden than it does. The minimum observed height was 28·735 inches at 2 A. M. At three o'clock the height was only a trifle greater than this, and, from the nature of the curve before and after the interval from two to three o'clock as well as from the velocity of the wind, it seems highly probable that between these hours a lower point than any observed was reached. The curve is constructed to show the actual vertical movement of the mercurial column. From the minimum it rose rapidly until 6 A. M., at which hour the height was 29·386 inches, and from that hour the rise continued with less rapidity but with great steadiness, until the night of the following Wednesday, when the reading was 30·378 inches. Thus the range of the barometer in three days was 1·643 inches. This is more than two tenths of an inch greater than the range for the whole of the last year. At no time during last year did the barometer reach so low a point as 29 inches, and the mean height for the year was 29·952 inches.

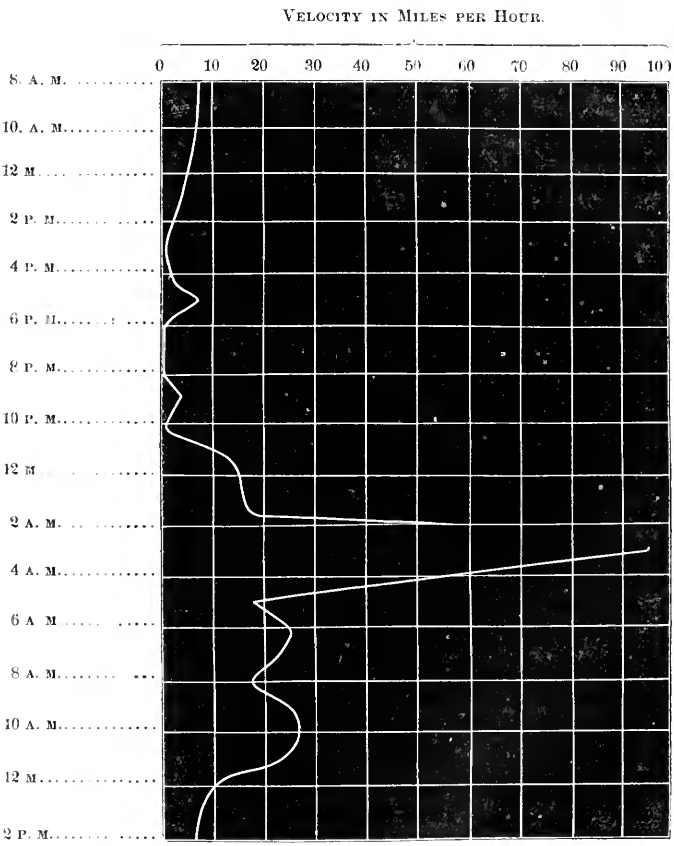
The second chart shows the velocity of the wind at different hours, extending over the same interval of time. These velocities are computed from a continuous record made by an anemograph consisting of a Robinson's anemometer with Beckley's registering apparatus attached. From this curve it will be seen that, so far as the wind is concerned, up to about 11 P. M., there were no indications of the coming storm. At that time a breeze sprang up, which continued at less than twenty miles per hour until about 1 A. M. when it suddenly increased in velocity, and at 2 A. M. the record shows a speed of sixty miles per hour. Unfortunately, shortly after two o'clock, the clock-work which keeps the registering portion of the apparatus in motion was stopped, the motion of the pendulum being undoubtedly arrested by a sudden blast of great violence. This stoppage was not discovered until 3 A. M., so that between these hours the record is lost. At three o'clock the instrument was put in motion again, and, for about fifteen or twenty minutes after that hour, the record shows the extraordinary velocity of ninety-five miles per hour. From this time the violence diminished rapidly, a velocity of fifty miles per hour being registered at 4 A. M., and at 5 A. M. it had fallen to less than twenty miles per hour. Twice afterward, as will be seen by the chart, the speed

rose to about twenty-five miles per hour, after which it rapidly declined.

Owing to the interruption in the continuity of these records, it is impossible to affirm that the maximum velocity of the wind was recorded. In fact, there are reasons for believing that the storm reached its greatest violence somewhat before three o'clock.

It seems quite certain, then, that at times during the storm the ve-

CHART SHOWING THE VELOCITY OF THE WIND FROM 7 A. M. ON THE 3D TO 2 P. M. ON THE 4TH OF OCTOBER, 1880.



NOTE.—The break between 2 A. M and 3 A. M. in the curve representing the velocity of the wind is due to the fact that, between those hours, the registering apparatus connected with the anemograph was not in motion.

locity of the wind exceeded one hundred miles per hour; and especially must this have been the case during some of the most violent blasts, which were generally of too short duration to show with their full effect upon the register made. The fact that the pendulum of the anemograph was stopped between two and three o'clock by one of these

blasts, and that after three o'clock its motion was not interfered with, would indicate that more violent disturbances took place before than after that hour. A smaller anemometer of Robinson's model was torn from its fastenings between two and three o'clock, and so completely demolished that no record even of the work which it had already done could be obtained. This is much to be regretted, as otherwise a means of verifying the extraordinary velocity registered by the anemograph would have existed. Concerning the latter it should be said that, regarding the smaller anemometer as a standard, it has been found upon examination to somewhat over-estimate the velocity of very high winds, and to under-estimate those of low speed. At the same time it can not be positively stated which of the two instruments was in error.

A continuous record of the direction of the wind is kept. Upon examining this it is found that, during the whole of the period considered, the direction varied between north and west. Up to 1 A. M., of the 4th, the wind was steadily from the north-northwest. From that hour until 5 A. M., its fluctuations were confined between northwest and west. A decided change in direction seems to have taken place between the hours of two and three o'clock.

The early part of the storm was accompanied by an unusually heavy fall of rain. The violence of the wind prevented the reading of the rain-gauges during the night, but when emptied at 7 A. M. they showed a total of 4·66 inches, nearly all of which must have fallen during—at most—two or three hours.

It may be interesting to make some comparisons between the violence of this storm and that which was undoubtedly the immediate cause of the destruction of the Tay Bridge, on the evening of December 28, 1879. Unfortunately, it does not appear that any very exact or reliable observations of the velocity of the wind on that occasion were made; but an approximate measure of it may be obtained from the testimony of several of the witnesses, who were men of considerable experience in the observation and estimation of high winds. The following selections from the "Times" report of the Board of Trade inquiry are of interest in this connection. Captain Scott, R. N., who was superintendent of a training-ship stationed in the Tay, testifies that his barometer fell from 29·60 inches at noon to 29 inches at seven o'clock—that being the lowest point reached. Also, that, in the navy, storms were described by numbers from 1 to 12, 12 being the maximum. Upon that scale he would describe this storm in the Tay as from 10 to 11. He had on rare occasions in China and the West Indies rated storms as high as 12.

Admiral William Heriot Maitland Dougal, who had resided at the mouth of the Tay continuously for twenty-nine years, stated that his barometer fell from 29·40 inches to 28·80 inches. The difference between these and the previous barometric heights is easily explained by

the fact that his house was at an altitude of two hundred feet above the level of the sea. He declared that the gale was like a typhoon in violence, and that in all the time during which he had lived on the Tay he had never experienced a gale of equal severity. In his opinion the velocity of the wind was from seventy-five to seventy-eight miles per hour, and that during the lulls it would fall to something like thirty.

Charles Clark, who was an amateur observer, gave evidence that 29·00 inches was the minimum point reached ; that he had marked the storm 4 on a scale of 6 ; and that he had never yet recorded 5 or 6.

Other witnesses testified in about the same way, all agreeing reasonably well as to barometric depression and probable velocity.

On comparing these statements with those already made concerning the recent typhoon here in Japan, it will be seen that both in barometric range and in wind-velocity the recent storm considerably exceeded that which was the occasion of the Tay Bridge disaster. The barometric change was not greater, but more sudden in the former than in the latter. Concerning the direct measurement of the pressure of the wind in pounds per square foot, it must be said that the instruments for doing this are, at present, to a great extent crude and unreliable. It is generally assumed that the pressure is proportional to the square of the velocity. Upon a scale adopted by the Smithsonian Institution and by the United States Signal Service, the velocity of twenty-five miles per hour corresponds to a pressure of three pounds per square foot. Assuming the correctness of this, and also of the law given above, the pressure per square foot in the Tay storm must have been nearly thirty pounds, and in the recent typhoon here it must have been nearly fifty pounds. It was shown, in the tests made upon the material of the Tay Bridge, that it might have been expected to give way under a wind-pressure considerably less than forty pounds. The French and many English engineers have adopted fifty-five pounds per square foot as a standard, and about the same number is used in America, but it seems doubtful if even that furnishes a sufficient "factor of safety."

In conclusion, the affirmation may be made, supported as it is by the constantly accumulating evidence of the damage done to buildings, shipping, etc., that this was one of the most violent storms experienced here for many years. From facts already known concerning other points along the coast of Japan, it would seem that, had an efficient system of observations, telegrams, and signals existed, timely warning might have been given of its approach, and possibly much property and many lives saved. In view of this fact it appears hardly necessary to repeat the suggestion, the importance of which has been frequently urged in these columns, that the Government should, at the earliest practicable moment, inaugurate an efficient and complete signal service for the benefit of the whole country.—*Japan Weekly Mail.*

ARTIFICIAL HYPNOTISM.

By Dr. R. HEIDENHAIN,
OF THE PHYSIOLOGICAL INSTITUTE OF BRESLAU.

THE people of the city of Breslau were, several months ago, greatly excited over the performances of a professor of animal magnetism who seemed to exercise extraordinary power. His subjects were taken indiscriminately from his audiences, and all, even physicians and men of science, who allowed themselves to be experimented upon, yielded to his control and contributed to his triumph. Dr. R. Heidenhain, Professor of Physiology and Director of the Physiological Institute of Breslau, on the invitation of the friends of science, delivered a lecture on the subject, in which he undertook to give a physiological explanation of the strange effects obtained by the magnetizer, and showed by experiment that the same results could be obtained by the sight or presence of inanimate objects. The following is an abridged translation of this address.—[Ed.

One of the essential symptoms of the hypnotic sleep is the more or less complete loss of consciousness. It is only in a complete state of hypnotism that persons subjected to the experiment preserve a remembrance of what has passed during their sleep. In some cases the memory is only suspended, and on awaking we may be able to revive the recollection by evoking an association of ideas which will put the subject in train. Sensorial perceptions take place even in the most complete hypnotism, but the power of transforming them into conscious representations, and consequently of fixing them in the memory, is absent. Have we not often had experience in the waking state of external perceptions which did not pass the threshold of consciousness because our attention was absorbed or distracted at the time? Have we not heard words pronounced around us to which we attached no meaning, which were nevertheless perceived by us, if we may speak in that manner, without our knowledge, since we may call them to mind by an effort of memory, provided they have not yet been effaced by a more recent impression?

The immediate affection of the senses and conscious perception are distinct physiological conditions, the latter of which supposes a holding of the attention. As the hypnotic's faculty of perceiving a sensation declines, his power of being conscious of it diminishes in a corresponding degree. Then, sensorial impressions which do not excite consciousness give way to movements which are accomplished almost without our control. A person walking in the street, absorbed in his thoughts, receives the visual impression of the passers-by on his retina without paying attention to them, and unconsciously performs the movements

necessary to avoid hitting them. The hypnotic is in a similar situation. Sensorial impressions of which he is not conscious provoke apparently voluntary and reasoned acts.

The hypnotic, although his eyes are shut, perceives what is passing around him. The eyelids are not wholly closed. Movements perceived unconsciously, by the aid of the sight or hearing, are imitated by him involuntarily and under a constraint from which he can not withdraw himself, and with an almost servile exactness. Thus he will regulate his step according to that of the experimenter who makes him act, will raise his arm to the same height, will bend his body back and forth in accord with his model.

Some acts of imitation, such as yawning, laughing, crying, etc., take place even in the normal condition ; generally the idea of a movement determines the action, but in induced sleep the contrary takes place, and the unconscious perception of a movement leads to its accomplishment. This relation explains the facility with which hypnotics are made to execute movements of which what we may call the sensation has been communicated to them in advance. If the subject is not disposed to follow the experimenter when he walks briskly in front of him to excite him, the operator has only to draw him lightly by the hand to make him follow with docility. We have thus explained the secret of the power which the magnetizer exercises over his subject. The former gives an order which the hypnotic does not apprehend, but which he executes nevertheless if he has unconsciously experienced a sensorial impression corresponding with the action which is commanded of him. In testing whether the hypnotic, after waking, remembers what has passed, it is important that he be not assisted by being asked a question the form of which will suggest the answer. If he is asked if he remembers any particular thing, his answer will always be "Yes" ; but if he is asked, generally, what has taken place, he will answer that he does not know. The slightest allusion may cause the remembrance to revive ; and unconscious traces may be recalled on the intervention of suggestive external excitations. The hypnotic condition, when divested of charlatanism, discloses a multitude of interesting physiological and psychological facts.

In a slight degree of hypnotism, the *sensorium commune* is still so free that the constraint of involuntary imitation does not exist. As long as consciousness is not obscured, the excitation of the motive apparatus by special sensations does not take place ; but when consciousness disappears, the sensorial excitation becomes predominant. So profound states of unconsciousness may be produced that all traces of sensorial perceptions, and the possibility of executing automatic acts of imitation, will disappear. A more advanced symptom of hypnotism is painlessness. Sensibility returns with the cessation of the sleep. The exaggeration of the reflex excitation of the striated muscles is also striking and of surprising duration. A person who has been hypno-

tized preserves the reflex irritability for whole days and weeks after he has returned to the normal state. When this excitation is light, the contraction is limited to the superficial muscles. In this condition it is easy to induce certain groups of muscles to contract. By passing the finger several times over the fleshy part of the thumb we may cause it to bend toward the palm of the hand; we may cause the head to assume the position known as that of a wry neck by exciting the skin over the sterno-cleido-mastoid muscle with a few light passes.

We may act on more remote muscles by prolonging the excitation. A light rubbing of the inside of the thumb only brings its adductor and flexor muscles into play. A stronger excitation of the same surface brings into action the muscles of the forearm and the flexors of the other fingers, which bend strongly toward the hollow of the hand. The muscles of the elbow and shoulder will be engaged in their turn, and in a short time the upper limb will become motionless. Continuing the passes, we may, in a few seconds, cause the contraction to extend to the left shoulder; the cramp will then descend along the arm, the forearm, and the hand of the left side; the left thigh and leg will yield to the same influence; then the right thigh and leg, the masseters and cranial muscles. It is time to pause. A slight shock on the left arm will cause the contraction to disappear. We can also cause it to cease by quickly opening the fingers of one of the closed hands.

Great prudence is necessary in these experiments lest they be carried too far, and the respiratory muscles be affected. The rigidity of the muscles may be made so great in robust persons that it becomes extremely difficult to change the position of the limbs. They are stiff as a plank, and it is possible to rest an hypnotic by his head and feet alone on two chairs, and carry him around without his body bending.

The first objective sign of the approach of the hypnotic condition is a rigidness of the accommodative apparatus of the eye. The assistants are able to perceive this before the hypnotic can feel it subjectively. The distance to which vision extends diminishes; writing which can be read from a distance can be distinguished only at close sight. Remote points disappear from the field of vision. In a few moments the pupil dilates, and the ball of the eye appears to project. The complexity of these phenomena supposes an excitation of the sympathetic nerve of the neck, which sets in motion the dilator muscle of the pupil and the smooth muscles of the lids and the socket. The initial point of the excitation must then be sought in the spinal marrow, where the sympathetic fibers originate. Other parts of the spinal marrow are not long in being affected, as the respiratory nerves, and the breathing is quickened. The aspirations increase from four to twelve in a quarter of a minute, but the frequency of the pulse is not increased.

Some persons are disposed to hypnotism in consequence of their

nervous impressibility, and of the power which imagination exercises over their minds. Others seem to be rebellious against it, and it is necessary to prepare them for it. The contemplation of the glass button exacted by M. Hansen (the magnetizer at Breslau) is intended solely to promote this excitability. Dr. Braid, of Manchester, first demonstrated that the fixed view of inanimate objects provoked a condition akin to the cataleptic sleep. Persons put to this sleep by him became insensible to pain. Some retained a feeling of what passed; others lost it. Fixing the sight upon bright objects is attended by peculiar phenomena. The dazzling effect, the flow of tears, and the fatigue of the retina cause the images on the edges of the field of vision to disappear. The hand that holds the button becomes indistinct and the button fades away. Phenomena of contrasts are produced, and posterior images appear during the involuntary movements of the eyes. Certain feeble and monotonous sounds act in a similar manner to produce stupefaction. If we cause a person to sit with his back against a table on which a watch has been put, and tell him to listen to its ticking, he will in a few minutes fall into the hypnotic sleep, and will then imitate unconsciously the motions of the operator. The effect is especially prompt if the eyes are kept shut. Light and continuous excitations on the surface of the skin exert a similar effect. This is the property on which depend the manipulations of touch and the passes which the magnetizer makes along the face of the person whom he wishes to put to sleep. These passes produce peculiar sensations, partly of contact and partly of heat. The sensations of contact at a distance are produced by the oscillations of the air, which is disturbed by the hand of the magnetizer. These currents occasion an almost imperceptible feeling of prickling, of shuddering. The sensation of heat is provoked by the difference in the temperature of the hand, which has been warmed by exercise, and of the motionless face of the patient.

The reactions to the different excitations vary according to the individual. Some persons are more sensitive to an excitation of the skin; others to that of the hearing or sight. The organs in which stupefaction is first felt are also the first to return to consciousness if they are subjected to an energetic shock. The touch of a cold hand on the face, a word spoken aloud at the ear, a light brought suddenly before the eyes, are enough to break the charm. After the waking, the disposition to hypnotism persists in a latent form. One who has been put to sleep many times has only to imagine he is going to fall into that condition, to go to sleep really. He has only to sit down, shut his eyes, and think, to the exclusion of every other idea, of the torpor which is about to overtake him, for the phenomenon to have its full effect. There is needed, in a word, to produce this effect, an exclusion of all change of thought and images. Having become acquainted with this disposition, we can produce effects which will be really inexplicable to

common people. We have only to tell a person who has been recently hypnotized that he will go to sleep at a certain hour, or in a certain place, or while doing a certain thing, for the phenomenon to be produced naturally.

The subject may be made to repeat words spoken before him, by pressing on the nape of his neck. Pressure between the fourth and seventh vertebræ of the neck makes him groan ; when applied at the side of the last vertebra, it induces him to draw his leg back ; and if made alternately on each side of this vertebra, will cause him to walk backward. Reflex local movements are provoked by the excitation of determinate points of the trunk : raising of the arms over the head, by irritation of the skin of the dorsal region of the pectoral vertebræ ; turning of the arm backward, by excitation of the skin over the middle vertebræ. If we apply a hearing-trumpet to the nape or the stomach of a hypnotic, he, although he may have been insensible to words pronounced in his ear, will comprehend articulate sounds and repeat them, even though they be in a language that is unknown to him. Hallucinations are produced only if the provoked sleep is light. The hypnotie symptoms may be dissipated by suddenly changing the excitation. If the magnetic state has been produced by passes before the chin, it can be made to disappear by reversing them. The contraction of the arm caused by rubbing the inside of the thumb ceases when the direction of the current is changed. A new sensation dissipates the effect of a previous excitation. It is not, then, a matter of indifference whether we change the direction of the passes : we should persevere in the one which was adopted in the beginning. Rigidity, if it is not intense, ceases on the application of a cold body ; a piece of money, a bit of glass, is enough to dispel it. If we touch the forehead or eyes of a hypnotic with a small piece of glass, he will open his eyes and mouth while sleep continues.

It has been asked if we can not obtain semilateral hypnotic phenomena by acting on half the face or head. In fact, by pressing along one side of the forehead or the crown of the head, we may diminish or suspend the influence of the will on the extremities of the opposite side. Light pressures on the left side of the head have produced immobility of the right arm and leg. A shock on the left arm caused this half-paralysis to disappear. The fixed limbs kept indefinitely the position which had been given them, and were found to be in a state of cataleptic suppleness. There appeared at the same time an impossibility to pronounce a word—a condition of ataxic aphasia. Passes on the right side of the head caused the same symptoms, less the aphasia, to appear on the left. Simultaneous passes on both sides of the head developed the cataleptic condition on both sides, aside from the disorder of speech and the facial movements. In all these experiments consciousness was preserved, without the accompaniment of any painful subjective impression. Lateral passes on the skin of the thigh pro-

duced singular disorders in certain sensorial impressions. The arm which was made cataleptic did not perceive the difference between a warm and a cold temperature. The eye on the affected side suffered a cramp of the accommodative muscle, and lost at the same time its normal sensitiveness to colors. The hypnotic condition can be explained only by hypothesis. All that is certain about it is, that it is due to a modification of the nervous centers of the brain and spinal marrow.

The apparently voluntary motions of persons in this condition are independent of their will, the sensorial impressions acting directly on their motive apparatus.

EXAMINATION OF THERMOMETERS AT THE YALE OBSERVATORY.

By Dr. LEONARD WALDO.

ONE of the most useful institutions to science in England is the Kew Observatory of the Royal Society, whose principal work for the last quarter of a century has been to furnish accurate comparisons of thermometers sent there by physicists, meteorologists, physicians, and instrument-makers. The recognized benefits accruing to the scientific world from this well-known and widely popular service at Kew have caused the managing board of the Winchester Observatory of Yale College to organize a service having the same ends in view under the direction of the observatory. Although this work is but fairly commenced, yet it has met with most gratifying success, and there have been so many inquiries as to the methods and scope of this service that the writer has ventured upon a description suitable for the pages of the "Monthly," with the hope that in this form it may the more readily come to the notice of the meteorologists and physicians who are the most likely to be benefited by it.

Few are aware of the errors found to exist even in the thermometers of reputable makers. The well-known change which takes place with age in every thermometer not infrequently amounts to a degree and a half Fahrenheit within two years from the time the thermometer is made. The change depending upon the temperature to which a thermometer is heated, even supposing this to be no greater than the boiling-point of water, may be three fourths of a degree. If we add to these two sources of error the original error in the graduation of the thermometer scale arising from the boiling and freezing points not being properly fixed, and the error arising from the variations in the size of the capillary tube, it is quite within the range of possibility that thermometers, which from their general construction would appear

likely to give correct indications, may really be in error two or three degrees Fahrenheit at some part of their scales. Thus the "fever" thermometers in general use by physicians are almost invariably too high in their readings. An analysis of the results of sixty-eight thermometers of this description, verified in June of this year, will show how great this error may come to be: one fifth had errors less than 0·1°; one fifth had errors less than 0·4° but more than 0·2°; two fifths had errors less than 0·7° but more than 0·4°; one fifth had errors less than 1·0° but more than 0·7°; and occasionally a thermometer was found which had errors exceeding 1° and more rarely one exceeding 2°. The thermometers on which the above deductions rest were chosen to represent seven makers, and may be fairly taken to indicate the liability to error in using fever-thermometers which have not been compared with authoritative standards. It is not unlikely that members of the medical profession have been sometimes misled by the readings of inaccurate thermometers, and they may have made such unfavorable statements regarding the chances of recovery of patients whose temperatures were high, that the patient, under the influence of his imagination, has given up the struggle for existence when a little more hopeful view of the case might have imbued him with fresh courage and led to ultimate recovery.

The work at the Yale Observatory divides itself into two parts—the establishing of the standard thermometers with which thermometers sent to the observatory are to be compared, and the work of comparing thermometers. The investigation of the standards themselves is by far the most tedious of the two; and as the methods used in studying the observatory standards are also the methods used, with greater or less detail, in investigating the higher grades of thermometers sent to the observatory, the methods will be briefly outlined.

It will be necessary to recall some of the fundamental principles of thermometry, however, in order to properly comprehend the methods of procedure in the case of standards:

1. Glass mercurial thermometers slowly increase their freezing-point readings as their age increases after the heating they undergo in filling with mercury in their manufacture.

2. The readings of the boiling-points are also increased, but in a much less degree—perhaps not more than one fifth as much as the freezing-point.

3. Whenever the thermometer is heated at all, the freezing-point is lowered, and the amount of this depression is very nearly proportional to the square of the temperature to which the thermometer is heated.

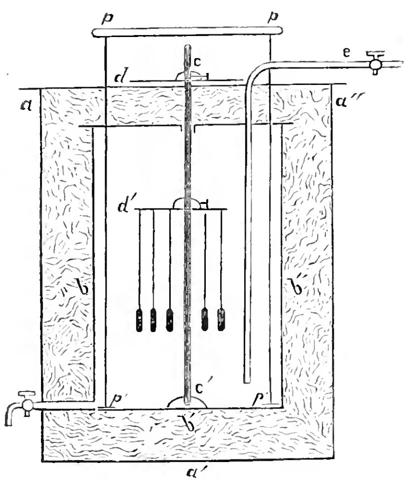
4. It follows from 3, that if a thermometer is kept at the ordinary temperatures, the freezing-point of water will be indicated by a lower scale reading than if the thermometer is kept at a low temperature. Now, if we suppose the thermometer has been kept at the freezing-point of water for a period of several days, and that the progressive

change which takes place in the first years after manufacture has ceased, the freezing-point which is then determined is called the permanent freezing-point, and is the zero of the Centigrade scale, or 32° of the Fahrenheit scale. If we heat the thermometer to the boiling-point of water, and then immediately cool it and immerse it in melting ice, we shall obtain another point on the thermometer scale which we may call the temporary freezing-point, because it will gradually approach the permanent freezing-point, and after a few months, if the instrument is not again heated, it will finally coincide with it. The difference between the permanent and temporary freezing-points is usually about three fourths of a degree Fahrenheit, and, so far as now known, remains constant for the same thermometer.

5. The boiling-point of water at the level of the sea, and with a barometric pressure of 760 mm. = 29·922 inches in the latitude of 45°, is the second point in the thermometer scale to be fixed. To do this the thermometer is exposed to the steam of pure water, and, from the observed height of the barometer, the known elevation and latitude of the place of observation, the true boiling-point is computed from the observed one, and the 100° C. or 212° F. is thus fixed.

6. Having thus located the freezing and boiling points of a standard thermometer, the intermediate points are to be fixed by dividing the scale so that at every part the length of 1° shall measure an equal

FIG. 1.



volume of mercury. At least, this has been the usual procedure, and for ordinary standards perhaps it is the most convenient. For standards to be used in the highest class of work it would be better to graduate the distance between 0° and 100° C. into one hundred equal parts, and then allow the observer to accurately determine the value of the corrections at each degree. Indeed, it is preferable for many

researches that the whole scale be simply a millimetre one, and care only be taken to have the millimetre graduation extremely accurate.

The dividing of the tube so that an equal volume of mercury may occupy the same number of degrees at the various parts of the tube is called the calibration of a thermometer, and on the perfection of this work, if it is attempted at all, largely depends the value of the thermometer. As Pernet has remarked, the labor of determining the errors of a thermometer is much increased by having to determine the errors the maker has introduced in the imperfect calibration of its scale. In observations not requiring an accuracy beyond 0·1° F., it it might be quite safely left to the skill of a reputable maker to free the instrument from errors of this kind. It is accomplished by detaching a small portion of the column and measuring its length at different, and usually consecutive, parts of the tube. Obviously from these results may be computed the value of 1° at successive parts of the thermometer scale, in terms of the dividing engine used by the maker.

The precision attained in the calibration of standards when the greatest care is exercised is surprising; thus, in the three Kew standards of the Yale Observatory, the maximum sum of the errors depending on imperfect calibration is very nearly 0.01° in each of them.

Supposing that several thermometers, by different and equally skillful makers, have been prepared with the greatest care, it is found in comparing them that they differ sensibly among themselves, owing to the difference in the glass used in their construction, their varying sensitiveness to the slight changes caused by the circulation of the water in which they are immersed, and a variety of less obvious causes. It becomes necessary, therefore, that some definite construction of the mercurial standard thermometer should be adopted, and the standard chosen by the Yale Observatory is defined upon the certificates issued with standards compared, as follows:

"The theoretical mercurial standard thermometer to which this instrument has been referred, is graduated by equal volumes upon a glass stem of the same dimensions and chemical constitution as the Kew standards 578 and 584. The permanent freezing-point is determined by an exposure of not less than forty-eight hours to melting ice, supposing the temperature of the standard has not been greater than 25° Cent. = 77° Fahr. during the preceding six months. The boiling-point is determined from the temperature of the steam of pure water at a barometric pressure of 760 mm. = 29·922 inches (reduced to 0° Cent.) at the level of the sea and in the latitude of 45°."

This standard has its 0° and 100° C. identical with the standard of the International Commission of Weights and Measures, and the physicists generally have agreed upon the pressure and latitude given as the most advisable. It is practically coincident with a pressure of 29·905 inches in the latitude of London, and at the sea-level—the con-

ditions under which the 212° point of the English standard is determined under act of Parliament.

A description of the Kew standards referred to is given in the accompanying table :

Maker.	Maker's Number.	How Graduated.	Length of 1°.	Smallest Graduation.	Length of Tube.	Shape of Bulb.
Kew Observatory..	585	— 34° to + 275° C.	1·73 mm.	1°	618 mm.	Cylindrical.
Kew Observatory..	578	— 9 to + 105 C.	3·46 "	0·5	455 "	"
Kew Observatory..	584	+ 14 to + 220 F.	1·87 "	1	455 "	"

The tubes of which the Kew standards are made are about twelve years old, and belong to the series purchased by the Royal Society and deposited at Kew to be used as standards.

The essential parts of the water comparator in use at Yale for comparing thermometers is shown in outline in Fig. 1, where $a\ a'\ a''$ is a bright-tinned iron cylindrical tank 15 × 20 inches, having an aperture for the stopcock *f*, a lid $a\ a''$ with various apertures for the insertion of long thermometers, and having a plate-glass window 4×14 inches set in the side. Within this outer tank a smaller copper tank 11×15 inches is symmetrically placed, and rests upon wooden bars which are supported by the bottom of the outer tank. A window, placed in the same relative position as the outer window, allows the thermometers which are attached by springs at their upper ends to the adjustable brass disk d', to be read. The brass axis $c\ c'$ turns in a bearing c', and has attached to it two disks, d, d'. A small cathetometer with its telescope is placed before the windows, and the number of the thermometer under observation is shown by means of the graduated dial at *d*. Water of a given temperature is admitted through the tubes at *e*, and after the temperature has been brought to the degree required, it is thoroughly agitated by moving vertically the ring plunger shown at $p\ p\ p'\ p'$. The disk d', which is perforated, will accommodate sixty-four thermometers. The agitation of the water having subsided, the thermometers to be compared are read as rapidly as possible, first from left to right and then from right to left. Two standards are read at the beginning and end of the series. It is obvious that, if they are read at approximately equal intervals, the mean of the two readings will be free from the error of radiation caused by the slow cooling or warming of the water. The greater part of the work of the observatory upon standards is done with this comparator. For clinical thermometers a smaller apparatus, constructed on the same general principles, is used ; but, as in this case a much less degree of precision is desired than in the investigations of standards, the work may be simplified. It is not necessary, for instance, to resort to the somewhat tedious read-

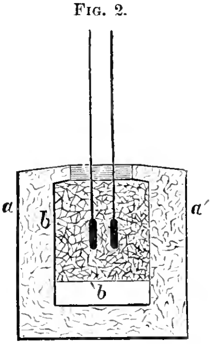
ings with the cathetometer, and since the thermometers are self-registering, they may be lifted from the water to be read.

The space between the outer and inner tanks is filled with cotton-wool which has been picked with the fingers until it has as little body as possible. The object of this wool is to prevent currents of air, which would otherwise cause a much greater conduction of heat to or from the body of water in the inner tank.

The determination of the freezing-points of standards is accomplished by the apparatus shown in Fig. 2, where a a' is a tinned-iron cylindrical vessel 9×9 inches, inclosing a smaller one $7\frac{1}{2} \times 5$ inches. A strainer allows the water from the finely crushed ice or snow to escape into the open space b', and the space between the outer and inner vessels is filled with cotton-wool. Close-fitting covers prevent currents of air from the outside, and when in use each thermometer is fitted to a cork which is imbedded partly in the ice.

One boiling-point apparatus is constructed after Regnault's plan, and consists essentially of a brass stand (Fig. 3) supporting a water-tank w w', 6 inches in diameter and 3·5 inches deep, upon which in turn rests a brass section of double tubing having an inside diameter of 5 and an outside diameter of 6 inches. This section, which extends upward 3·1 inches, has three open tubes each 0·7 inch in diameter (v v') let into its outer wall. At the place which would be occupied by the fourth there is a small manometer-tube m, with a stopcock s, by which the difference of the pressure of the steam inside and the air outside may be noted. Any one of a series of four brass double cylinders, ranging in height from three to twelve inches, may be fitted to this first section by a telescope-joint at will. Each of these double cylinders has perforations at its top for the insertion of thermometers. Around the top of the inner cylinder there is a series of ten holes, each three fourths of an inch in diameter, to allow the steam to pass from the inner chamber to the outer, and thus through the vents v v' to make its escape. When in use, the tank w w' is filled with pure water, taking the precaution to put several feet of brass ribbon in the bottom to equalize the boiling; and the heat is communicated by means of the Bunsen burner b'. The thermometers are suspended as at t t', with their bulbs at b.

Fig. 2.

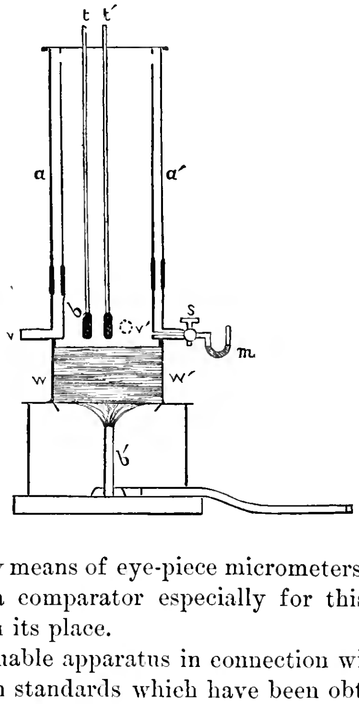


Another boiling-point apparatus, to be used for very long thermometers, and where it is desirable to take the greatest care in the boiling-point determination, is made entirely of glass. The thermometer is completely immersed in steam, and the readings are made with the cathetometer by looking through the glass and steam which surround the thermometer.

A standard barometer, wrapped in cotton-wool and cloth to prevent rapid change in the temperature of its mercury, and made by James Green, is hung on the same level as the boiling-point apparatus, and the thermometers are read alternately with the barometer. The cathetometer is used for reading thermometers in both the boiling and freezing-point apparatus.

For the calibration of tubes, two microscopes have been mounted so that the position of the two ends of a short mercury-column may be

FIG. 3.



read at the same time by means of eye-piece micrometers. The observatory is having built a comparator especially for this work, which will soon be mounted in its place.

By far the most valuable apparatus in connection with this work is the collection of foreign standards which have been obtained to represent the work of foreign observatories. This collection comprises seventeen standards of the highest class, eight working standards, and forty-five comparison thermometers. The makers comprise noted artists of Europe, and among them are the Kew Observatory; Baudin, Fastré, Tonnelot, and Alvergniat, of Paris; Fuess, and Greiner & Geissler, of Berlin; and Casella, of London.

The comparison of the important standards was undertaken by the Kew Observatory in England, the Seewarte at Hamburg, and the Imperial Commission of Weights and Measures, under Dr. Foerster, at Berlin. There can be little doubt, therefore, that the observatory of Yale College possesses an accurate copy of the standard thermometers now in use in the prominent observatories in Europe.

It is the object of the observatory to make this service as widely

popular as possible; and it particularly desires to be useful to the physicians, meteorologists, and the commercial manufacturers who have occasion to use fairly accurate thermometers. The testing of illuminating oils, the manufacture of spirits and ethers, and the numerous operations of the chemical laboratory, require thermometers of considerable accuracy, and for the benefit of persons using such the observatory has issued a circular which will be mailed on application.

Thermometers may be sent by mail or express, directed to the Winchester Observatory, New Haven, Connecticut. If they are sent by mail (and nothing larger than a clinical thermometer should be), they ought to be packed in a wooden box, in tissue-paper. In whatever manner they are sent, a little care taken in packing them in soft paper will materially lessen the risk of accident. Ordinary thermometers are returned to the senders, with certificates stating their deviation from the true mercurial standard for every ten degrees, within a few days from the date of their reception. Standards require from a week to a month for their investigation, depending upon the degree of precision desired in the final certificates.

The official circular of the observatory contains detailed information relating to the supervision of hospital thermometers and the facilities offered to makers. There is no good reason why any maker should not furnish, with any thermometer sold, a certificate stating the errors of that particular instrument. That the service will be a popular one is shown by the fact that already about five hundred thermometers have been sent to the observatory for verification, and not the least benefit will be that the errors of every thermometer issued with a certificate will be on file at the observatory, and this will be of particular value in cases where a uniformity of data is desired, as in the case of the United States Signal Service, or the observations made by isolated meteorologists in different parts of the country.

INDIGESTION AS A CAUSE OF NERVOUS DEPRESSION.

By T. LAUDER BRUNTON, M.D., F.R.S.

II.

BUT bile is not the only substance which produces a depressing effect upon the circulation when absorbed into it from the portal system. I have already mentioned that certain albuminous products of intestinal digestion and peptones occasionally make their appearance in the urine. Among the former is an albuminous substance, not precipitated by boiling, but by nitric acid in the cold. This sub-

stance I have observed in the urine of a healthy man after he had drunk a large quantity of strong beef-tea at a draught upon an empty stomach. My attention was drawn to the urine by the froth remaining upon it for a somewhat unusual time. On examination, this substance was discovered in it. On examining the beef-tea which the person had taken, a similar albuminous substance was found in it, so that there can be little doubt that in this case the albumen was simply absorbed so rapidly from the stomach or intestines that it passed without change through the portal system into the general circulation, and thus reached the kidneys, where it was excreted in much the same way as sugar would have been under similar circumstances. We find only too frequently that both doctors and patients think that the strength is sure to be kept up if a sufficient quantity of beef-tea can only be got down; but this observation, I think, raises the question whether beef-tea may not very frequently be actually injurious, and whether the products of muscular waste which constitute the chief portion of beef-tea or beef-essence may not under certain circumstances be actually poisonous. For although there can be no doubt that beef-tea is in many cases a most useful stimulant, one which we find it very hard indeed to do without, and which could hardly be replaced by any other, yet sometimes the administration of beef-tea, like that of alcoholic stimulants, may be overdone, and the patient weakened instead of strengthened. In many cases of nervous depression we find a feeling of weakness and prostration coming on during digestion, and becoming so very marked about the second hour after a meal has been taken, and at the very time when absorption is going on, that we can hardly do otherwise than ascribe it to actual poisoning by digestive products absorbed into the circulation. From the observation of a number of cases I came to the conclusion that the languor and faintness of which many patients complained, and which occurred about eleven and four o'clock, was due to actual poisoning by the products of digestion of breakfast and lunch; but at the time when I arrived at this conclusion I had no experimental data to show that the products of digestion were actually poisonous in themselves, and only within the last few months have I seen the conclusions to which I had arrived by clinical observation confirmed by experiments made in the laboratory. Such experiments have been made by Professor Albertoni, of Genoa, and by Dr. Schmidt-Mühlheim, in Professor Ludwig's laboratory at Leipsic.

Professor Albertoni has found that peptones have a most remarkable action upon the blood, completely destroying its coagulability in dogs, while they have little power in this respect over the blood of rabbits or sheep. The number of species upon which he experimented is limited, so that he can not as yet draw the conclusion with certainty that peptones prevent the coagulation of the blood in carnivora and not in herbivora, although, so far as experiments go, this conclusion seems probable. He and Dr. Schmidt-Mühlheim independently made

the discovery that peptones prevented the coagulation of the blood in dogs, and the latter, under Ludwig's direction, has also investigated their action upon the circulation. He finds that, when injected into a vein, they greatly depress the circulation, so that the blood-pressure falls very considerably; and when the quantity injected is large, they produce a soporose condition, complete arrest of the secretion by the kidneys, convulsions, and death. From these experiments it is evident that the normal products of digestion are poisons of no inconsiderable power, and that if they reach the general circulation in large quantities they may produce very alarming, if not dangerous, symptoms.

Such experiments as this open up a new and very wide field of inquiry, which is likely to prove of very great practical importance. We have hitherto been accustomed to reckon all peptones as identical, by whatever digestive ferment they were formed, and to look upon it as a matter of slight moment whether albuminous foods introduced into the digestive canal were dissolved by the stomach or by the pancreas, although it is quite possible that the peptones differ as much from each other as different kinds of sugars. It is a matter of wonder, also, that at the present moment, although the digestive processes have been so carefully investigated, we know very little of the uses of the *succus entericus*. Notwithstanding the great extent and evident importance of the intestine, and the large quantity of fluid which it is able to secrete, all that we find regarding the action of this secretion in such a book as Foster's "Physiology" is that "the statements with reference to its action are conflicting. Probably it has no direct action on either fats or proteids, but is amylolitic in some animals, though not in all." *Succus entericus* has also been said to change cane- into grape-sugar, and by a fermentative action to convert cane-sugar into lactic acid, and this again into butyric acid, with an evolution of carbonic acid and free hydrogen. The reason why experiments on the action of intestinal juice have given such an apparently unsatisfactory result is that they have been chiefly tried on such kinds of food as we are accustomed to put into our mouths. Now, the intestinal juice is not intended to act upon such substances: its place is to finish the digestion begun by the other juices; and when experiments with intestinal juice are tried upon foods which have previously been subjected to the action of the other digestive fluids, positive and not negative results are obtained. Thus, for example, it was stated by Kühne, in his lectures at Amsterdam in 1868–'69, that though intestinal juice would dissolve raw albumen and fibrine, it would not act at all upon them if boiled; but if the boiled albumen or fibrine were first subjected to the action of pancreatic juice for a short time, the intestinal juice would afterward dissolve them much more quickly than it would even in a raw condition. The action of digestive ferments is just beginning to find a practical application in medicine, and sometimes, undoubtedly, they are of very great service; but unless their action is investigated

more thoroughly than it has been up to the present, it is just possible that we may by and by find that the digestive ferments, like all other powerful agents, may do much harm as well as much good. Hitherto we have been accustomed to regard the phases of digestion, gastric digestion, pancreatic digestion, and intestinal digestion, as almost separate processes, any of which we might increase indefinitely without doing any harm to the patient. We forget the relation which each bears to the other; and yet such a relation undoubtedly exists, for we find that when pepsin is mixed with bile it is precipitated and rendered inert. Further transformation of foods by the gastric juice is thus arrested as soon as the chyme leaves the stomach. And well it is that this should be so, for if the pepsin were not rendered inert it would destroy that pancreatic ferment (trypsin) which acts on albuminous substances, and thus interfere with digestion by it. How far this prolonged peptic digestion and impaired pancreatic digestion of albuminous substances has to do with the production of poisonous digestive products in cases where the quantity of bile poured into the intestine is deficient it is at present impossible to say, but it is a condition which ought to be kept in mind in all cases where there is deficiency of bile in the intestine, and the advisability of nourishing the patient by farinaceous food is constantly considered in these cases.

And now comes the question, How is it that in healthy conditions of the intestine peptones do not pass into the general circulation, and are therefore unable to exert any poisonous action upon the nerve-centers? This question is one which we can not at present answer quite satisfactorily.

Usually the peptones disappear from the portal blood before it reaches the general circulation. Indeed, Ludwig and Schmidt-Mühlheim found that even in the portal blood, before it reaches the liver, very little if any peptone is to be found. They have not succeeded in discovering where the peptone undergoes change. Plósz and Gergyai, and also Drosdorff, have discovered peptone in the blood of the portal vein, and Plósz and Gergyai have been led, by their experiments, to regard the liver as the seat of the transformation of peptones. In consideration of the more recent experiments of Ludwig and Schmidt-Mühlheim, we can not entirely adopt the view of these authors, though it is nevertheless possible that they are to a certain extent right, and that the liver, to some extent at least, serves the purpose of preventing any peptones from getting into the general circulation, which may have escaped transformation in the portal blood before reaching it.*

And now, having run over in this cursory manner some points connected with digestion and with the functions of the liver, we come back to the question of why it is that the mental worker becomes de-

* Schmidt-Mühlheim, "Archiv für Anatomie und Physiologie; physiologische Abth.," 1. & 2. Heft, 1880, p. 33. Albertoni, "Centralblatt f. d. medicinischen Wissenschaften," 1880, p. 577.

pressed, irritable, melancholy, and, it may be, stupid and forgetful, after a few months' work, although every part of his body may be organically healthy, and a month's holiday may be sufficient to restore every organ to perfect functional activity? One reason, no doubt, may be that his systematic overwork may produce a diminution in the energy-yielding substance of his nerve-centers, just as we see that a certain amount of atrophy occasionally occurs in overworked muscles. But this does not seem very probable. It seems much more likely that they cease to act in the normal way because, during each day's activity, a certain amount of waste product is formed which is not perfectly removed during the hours of rest.

All throughout the body we have most elaborate arrangements for removing waste products. In the muscles, for example, we find that the fascia which surrounds them forms a regular pumping arrangement, the two layers of which it consists being separated from each other at each muscular relaxation, and pressed together at each contraction.* The lymph and the waste products which it contains are thereby actually pumped out of the muscle at each contraction, and sent onward into the larger lymph-channels, so that the muscular action itself removes the waste products. At the same time we find that the movement of the muscles of the leg, for example, will also pump out the blood from the veins, sending it upward from the feet, and pressing it upward to the body.†

Again, we find that in the abdomen and thorax we have pumping arrangements, whereby any excess of the serous fluid which bathes the intestines and lungs is pumped out of the peritoneal pleural cavities by the action of respiration. The two layers of the central tendon of the diaphragm and of the pleura here form pumping arrangements similar to the fascia in the leg.

The brain and spinal cord, being inclosed in rigid cases, have no pumping arrangements in immediate connection with them, but the circulation of the cerebro-spinal fluid in them is probably affected also by the movements of the thorax and abdomen. The cavity of the arachnoid and of the cerebral ventricles is not only continuous with similar cavities in the spinal cord, but also with the lymph-space surrounding the choroid, with the interior chamber of the eye, and even with the lumbar lymphatics; and Professor Schwalbe has succeeded in injecting these parts by a single insertion of the nozzle of his injecting syringe into the arachnoid. His observations have been confirmed and extended by Althann.‡ The experiments of Quincke have shown that during life a current exists in the cerebro-spinal fluid, both from above downward and from below upward.§ The cause of this current

* Ludwig and Genersich, p. 53, "Ludwig's Arbeiten," 1870.

† Braune, "Ber. der sächs. Gesell. d. Wiss.," 1870, p. 251.

‡ Althann, *vide* "Virchow's Jahresbericht," 1872, p. 156.

§ Several authors, as Abel Key and Retzius ("Nordisk medicinsk Arkiv.," 1870,

is, in all probability, the respiratory movements. We have, indeed, in the brain and spinal cord, a condition not unlike that which exists in the fascia covering muscles, where the muscular substance during its contraction presses flexibly the inner against the unyielding outer layer of the fascia, and thus produces, in the space between them, a pumping action. The skull and vertebral canal would correspond to the hard outer layer or fascia ; and the brain and cord, which, as we know, expand and retract during the movements of respiration, when a part of their bony case is removed, will have a similar pumping action upon the cerebral spinal fluid to that of the muscle upon the lymph in the fascia.

In the case of the brain and the cord there will be, in addition, a pumping action produced by the very circulation of the blood in them, the alternate expansion and dilatation corresponding to the heart's beats, having a similar effect to that produced by the respiratory movements. As stimulation of the brain causes dilatation of its vessels, and increases the flow of blood through them, mental action of itself not only attracts more blood to the brain, but provides to some extent for the removal of waste products. The movements induced by the cardiac pulsations are not so extensive as those caused by the respiratory movements or by muscular exertion, and therefore, when the brain is overworked, and the respiration and muscular movements are underworked, the cerebral nutrition will be diminished by the imperfect removal of waste from its substance. But if, in addition to this, the cerebral cells and fibers are actually poisoned by the circulation within the vessels which supply them, of noxious substances due to imperfect digestion or assimilation, matters will become very much worse.

We have already seen how much the liver has to do with such a condition. Now, while the brain is being taxed to its utmost, the worker generally gets but very little exercise. The consequence of this is, that although the respiratory movements still go on with regularity, and the pressure of the diaphragm upon the liver at each respiration presses the bile more or less out of the liver, yet the pressure thus exerted is very much less than would be the case if the individual were making occasional vigorous efforts during which the breath was held, and the muscles of the abdomen put into action, as, for instance, in springing from bowlder to bowlder on the moraine of a Swiss glacier. So long as the brain-worker is exceedingly careful what he eats, so that no excess of bile is formed, and is fortunate enough to escape duodenal catarrh, so that no impediment, however slight, prevents the flow of bile into the intestine, he may get along perfectly well ; but if he be unfortunate enough to get what is commonly known as cold in

II, 1, 13–18; "Centralblatt für Medicinischen Wissenschaften," 1871, p. 514); Quincke ("Reichert's und Du Bois-Reymond's Archiv," 1872, 153–177; "Centralblatt für Med. Wissen.," 1872, p. 898).

the stomach, or unwary enough to irritate the mucous membrane of his stomach or duodenum by wines or spirits, the case is at once altered, for now the swollen mucous membrane of the duodenum tends to close the orifice of the bile-duct, or the congestion may even extend up the duct itself. Thus an impediment, however slight it may be, is opposed to the exit of bile from the liver. The pressure under which the bile is secreted, as I have already said, is very small, and there being no extra pressure put upon the liver by the diaphragm and abdominal muscles, instead of the bile being at once forced out of the bile-capillaries it will remain in them, causing more or less congestion, and now follows a whole series of disagreeable results. The bile, which may be looked upon as a waste product of the liver, not being removed, the other functions of the liver are disturbed. Assimilation becomes imperfect, we find lithates appearing in the urine; the circulation in the liver itself may be altered, and thereby the whole circulation in the stomach and intestines may be impeded, for it must be remembered that all the blood from the stomach and intestines has to pass through the liver before it again reaches the general circulation. Thus the individual becomes troubled with hæmorrhoids, secretion and vermicular movement in the bowels are impaired, so that constipation results; congestion of the stomach, with loss of appetite, impaired digestion, and flatulent eructations ensue, and the brain and nervous system begin to suffer from the accumulation in them of their own waste, or the absorption of abnormal products of assimilation.

Feeling weak, dull, and melancholy, the sufferer now thinks he ought to take meat three times a day, and perhaps, during the intervals of his meals, to take strong beef-tea, or perhaps a glass of wine or a nip of brandy. Yet, in spite of all this, he becomes weaker, more stupid, and more melancholy; and no wonder. He is simply further overtaxing his already overworked digestive organs. He is piling up fuel, instead of removing ash, and choking the vital processes both in his digestive and nervous systems. What he wants is not more nutriment, but a more rapid removal of waste, and the change upon the adoption of a proper system of treatment is in many cases most marked and satisfactory, both to the physician and the patient.

The first thing to be done is to clear out the liver. This may seem to be an unscientific expression, one adapted rather to popular notions than in accordance with ascertained facts. But this is not the case. In a former paper on the action of purgative medicines,* I have explained the way in which certain purgatives may be said to have the effect of clearing out the liver, and first among those we must reckon mercurials. In the case which we have just been describing, five grains of blue-pill may be taken every night, or two or three grains of calomel either alone or combined with extract of hyoscyamus or conium, and this should be followed next morning by a saline draught.

* "Practitioner," vol. xii, pp. 342, 403.

As a saline we may use sulphate of magnesia, or Friedrichshall, Pullna, Hunyadi Janos, or Carlsbad water; but, whichever saline we may choose, the use of one or other of them should on no account be omitted. One of the best salines is half a drachm of crystallized Carlsbad salts dissolved in a tumbler of hot water and drunk immediately after rising in the morning, and this may be used not merely in the morning after the mercurial, but it may also be employed every morning in cases where the bowels are constipated. The quantity of water is of considerable importance. Half a teaspoonful dissolved in a full tumbler is more efficacious than double the quantity of salt in half the quantity of water. Nor is this to be wondered at, for not only has the larger quantity of liquid greater power to wash out the intestine, but the increased amount of the water tends to increase the quantity of bile secreted, and this increase in bile is especially marked when the water is taken frequently in small quantities, as it is by persons undergoing the cure at Carlsbad, or who take the solution of Carlsbad salts at home by sipping it at intervals while dressing, instead of drinking it all off at once.

Zawilski found that when liquids were taken in this way not only was the bile secreted in greater quantity, but under a greater pressure, so much so that secretion still occurred when such an obstruction was opposed to its exit as would usually have caused the bile which had already been excreted to be reabsorbed.*

When the Carlsbad salts are employed after the mercurial, it is, I think, best to take them in single large draughts immediately on rising, but when used by themselves the solution should be sipped at intervals during dressing. When used alone, the Carlsbad water, warmed by standing the tumbler in a basin of hot water or in an ætna, is perhaps even better than the salts, which represent only a part of the normal constituents of the water. After the liver has been thoroughly cleared out in this manner by a mercurial purgative followed by a saline, vegetable cholagogues, such as iridin and euonymin, may be employed to assist the action of the Carlsbad salts, when these are found to be insufficient, even although they are taken with regularity. These cholagogues, the introduction of which into medicine, in this country at least, we owe to Professor Rutherford, are sometimes as useful, perhaps even more so than mercury, but, as a rule, I think the mercurial purgative is the best to begin with. Euonymin is the cholagogue most usually employed, but iridin is really the most powerful one, and is specially recommended by Dr. Rutherford.

Instead of trying to keep up the strength, as it is termed, by loading the stomach with food, the exhausted brain-worker should rather lean toward abstinence from food, and especially toward abstinence from alcoholic liquors. The feeling of muscular weakness and lassitude, which I have already had occasion to mention as frequently com-

* "Sitzungsber. der wiener Acad.," 1877; mat. nat. Abth., Bd. iv, p. 73.

ing on about two hours after meals, is not uncommonly met with in persons belonging to the upper classes who are well fed and have little exercise. It is perhaps seen in its most marked form in young women or girls who have left school, and who, having no definite occupation in life, are indisposed to any exercise, either bodily or mental. I am led to look upon this condition as one of poisoning, both on account of the time of its occurrence, during the absorption of digestive products, and by reason of the peculiar symptoms—viz., a curious weight in the legs and arms, the patient describing them as feeling like lumps of lead. These symptoms so much resemble the effect which would be produced by a poison like curare, that one could hardly help attributing them to the action of a depressant or paralyzer of motor nerves or centers. The recent researches of Ludwig and Schmidt-Mühlheim render it exceedingly probable that peptones are the poisonous agents in these cases, and an observation which I have made seems to confirm this conclusion, for I found that the weakness and languor were apparently less after meals consisting of farinaceous food only. My observations, however, are not sufficiently extensive to absolutely convince me that they are entirely absent after meals of this sort, so that possibly the poisoning by peptones, although one cause of the languor, is not to be looked upon as the only cause. A glass of soda-water, with or without the juice of a lemon squeezed into it, may be slowly sipped when the feeling of weakness comes on, and a biscuit may be eaten along with it if desired. This will sometimes relieve languor, but if it be found insufficient, a small cup of warm but weak tea or cocoa with a biscuit will act as an efficient stimulant, although they may be less unobjectionable than the soda-water. Heat is one of the most powerful of all cardiac stimulants, and any warm fluid in the stomach will increase its action; a cup of warm water alone will do this, but it is unpleasant to take, and so something must be added to flavor it: a little claret may be used if tea disagrees, or tincture of ginger and sugar, or even some Liebig's extract. It is the local action of the warmth that we want, and in order to obtain it we may sometimes have to put up with the inconvenience of giving substances which will be to some extent injurious after their absorption, such as beef-extract or even whisky. The advice that I have given here, in recommending a glass of cold soda-water or a cup of hot tea, may remind one of the countryman in one of Æsop's Fables who fell into disgrace because he blew upon the fire to heat it, and blew upon his porridge to cool it. And yet the countryman was right, for experience had taught him that the desired result would follow his actions, even though he might not be able to explain the reason why. So we find that a draught of cold water will revive a fainting person, and hot water will have a somewhat similar effect. Both of them give relief by stimulating the circulation, but their *modus operandi* is different. In the case of the hot water the circulation is stimulated

through the heart, which is excited to increased contraction, and thus the tension within the vessels is raised. In the case of the cold, the pressure is also raised, not by stimulation of the heart, but by the contraction of the vessels, especially those of the stomach and intestine. In the case of warmth, more blood is poured into the aorta by the excited heart, and where we apply cold less blood flows out of the aorta into the veins through the intestinal vessels, and thus it is that in both cases the tension is raised and the faintness removed.

At each meal it is well for the patient to begin with the solids before he proceeds to the fluids, and at breakfast, instead of beginning the meal with a cup of tea or coffee, he should finish a slice of dry toast and a piece of fish, egg, or bacon, before he takes any liquid at all. The same rule should be observed at lunch and dinner. The effect of this course is that the patient is less troubled with weight and flatulence after meals. The explanation of the fact probably is that the solids, entering the stomach first, stimulate it to secretion and movement ; whereas, if it already contained a quantity of liquid at the time they were ingested, they would not have this effect, and imperfect digestion would be the result. At dinner, wine or beer may be taken if the patient finds them agree, but in all probability he will be better without them. There are some brain-workers who require them and must have them, but it is better for a good many others to avoid either wine or beer, and to take some effervescing water instead. Not unfrequently we hear the complaint that effervescing water is too cold, and where this is felt to be the case ginger ale or zoedone may be substituted, the color of these beverages and their more pungent taste rendering them more grateful both to the eye and the palate of many persons. In some cases weak claret-and-water may be used, and if the water be somewhat warm the mixture will be better for the patients, and will not cause the feeling of coldness in the stomach of which they sometimes complain.

A medicine which has long enjoyed a great reputation in disorder of the liver is nitro-muriatic acid, and I think this reputation well deserved. We do not know how it acts, but in some way or another it does tend to improve the digestion. Ten minims of the dilute nitro-hydrochloric acid, either before or immediately after meals, combined with some aromatic and carminative, such as chloroform and cardamoms or orange, and from five to ten minims of tincture of nux vomica, where the nervous depression is great, is a most efficient remedy.

But, even with all this care in food and drink, with all this attention to what is to be taken and what avoided, with medicine morning, noon, and night, how are we to keep the liver in order without exercise? Sometimes the patient may be able to take walking exercise, but when he does it is generally only for a short time during the day, and of so gentle a character that the respiratory movements are but

very slightly increased, and the liver is hardly more stimulated by the pressure of the diaphragm and abdominal walls during the walk than it would have been had the patient remained quietly at home. Time is an important element in many cases. Many a hard-worked man has his day so fully occupied that he can not give up more than a quarter or half an hour to exercise, and it is of importance that in this limited period he should get as much exercise as possible, and the best way to employ this brief time is by taking horse-exercise. I believe it is to the late Lord Palmerston that we owe the saying that "the outside of a horse is the best thing for the inside of a man," and it is very near the truth. A brisk trot for fifteen minutes will cause more pressure upon, and stimulation of, the liver than a lazy lounge of an hour or more. The time for this will depend in a great measure upon the engagements of the patient. It should not be taken immediately after a meal, and for most men whose days are fully occupied almost the only time to take it is before breakfast. A cup of milk, or a small cup of tea or coffee, with a piece of bread and butter or a biscuit, may be taken just before starting, and then the regular breakfast will be taken with greater appetite and better digestion after the exercise is over.

By careful attention to the removal of waste products, and to the prevention of absorption of poisonous substances from the intestine, by regulation of the diet, regulation of the bowels, and exercise, in the ways just mentioned, I believe that the nervous exhaustion and depression from which brain-workers suffer may be greatly diminished, even although it may not be entirely prevented.—*Practitioner.*

OIL-PLANTS OF FRENCH GUIANA.

By Dr. J. HARMOND.

THE flora of Guiana includes a considerable number of plants of different families whose organs contain fatty matters. The most important of these plants, both on account of the abundance and quality of the oil it yields, is the carapa (*Carapa Guianensis*, D'Aublet; *Xylocarpus carapa*, Spr.; crabwood of the English), a plant of the family of the *Meliaceæ*, the family of which the Pride of India is the best known representative. It is one of the largest trees of the country, reaching a height of from sixty-five to a hundred feet, and a diameter of from a yard to a yard and a half. The wood is of a grayish or reddish color, and of excellent quality, is much in demand on account of the ease with which it is worked, and is used for shingles, cabinet, carpenter's and carriage work. The leaves are abruptly pinnate, with smooth, oval leaflets about a foot long and ending in a projecting

point. The fruits are round, four-valved capsules, about three inches in diameter, and grow in bunches. They inclose a white, solid kernel of irregular shape and firm consistency. To get the oil, the natives boil the kernels in water and let them stand in a heap for a few days. They then peel them, crush them with stones or pound them in wooden

FIG. 1.—CARAPA GUIANENSIS—FRUITS AND LEAVES (reduced).

mortars, and make a paste of them which they spread on a slab of stone hollowed out, and exposed at a slight inclination to the heat of the sun. The oil with which the paste is impregnated runs into a calabash which is placed to receive it. The negroes on some of the plantations put the paste into a bag and press the oil out with weights. The

carapa-tree appears to have been formerly more abundant in the inhabited districts than it now is, but it has been sought after on account of the qualities of its wood till it has nearly disappeared. It is still very abundant in the interior, where it grows near the rivers, and on moist lands. In some places, it is said, the ground is so thickly cov-

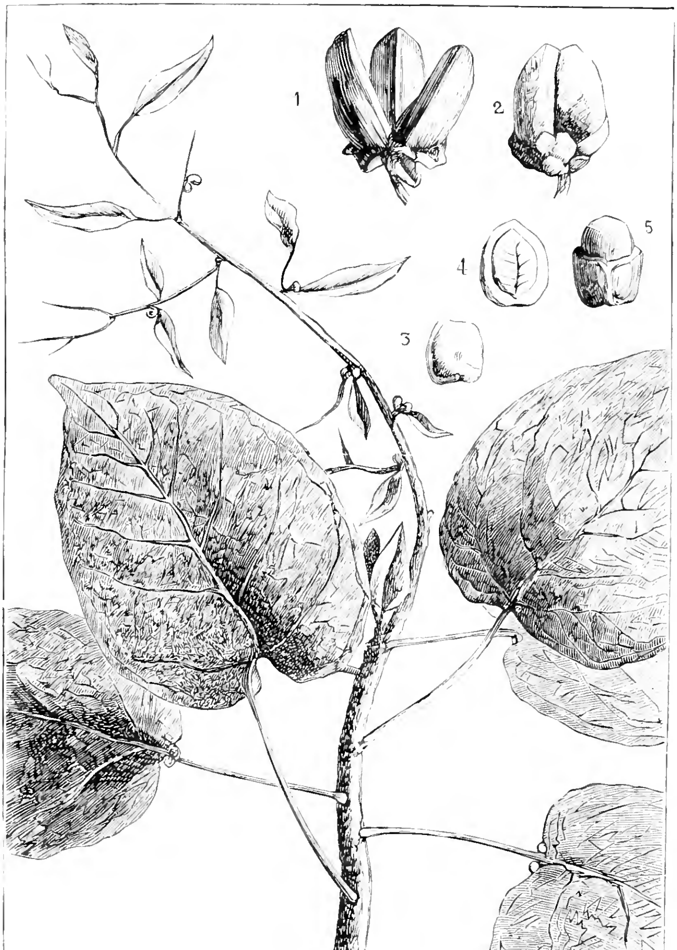


Fig. 2.—Omphalea Diandra (D'Aublet). 1, 2. Fruit, splitting into three nuts; 4. Internal face of cotyledon; 5. Nut with a part of the shell taken away, showing a part of the kernel.

ered with the fruits that they come up to the knees of a person walking among them. The principal crop is gathered between February and June or July. Another crop ripens in September and October, but the oil is of an inferior quality. The fruits do not keep well, but are subject to a mold which reduces them to dust, sprout readily, and are

greedily attacked by a grub and by microscopic enemies. The paste, too, is apt to spoil by heating. Hence it is found to be most economical to make the oil where the nuts grow. The nuts, when broken up with their coverings, yield about thirty-six per cent. of oil; cleared of their coverings, the kernels give sixty per cent. When cold-pressed, the oil is clear and amber-colored. When left to stand, it gives a solid deposit of a crystalline appearance. It makes a soap of excellent quality, and having a certain degree of hardness—a property which makes it valuable to mix with other oils that give too soft soaps. When refined, it makes an excellent lubricating oil, and gives a light that leaves nothing to be desired. The catalogue of the Permanent Exposition of the French Colonies names some fifteen other species of plants the fruits of which yield oils. One of the most valuable of them is the *Omphalea diandra* (D'Aublet), a large vine of the Spurge family, which bears seeds with very hard and black, horny shells. The shells are used for making beads. The kernel contains a very limpid, amber-colored oil, which is excellent for illumination, for making soap, and for lubricating purposes, and of which the yield is 64·58 per cent.

CRITICISMS CORRECTED.

By HERBERT SPENCER.

III. GUTHRIE AND BIRKS.

CRITICISM would be greatly diminished in bulk if there were excluded from it all that part devoted to disproving statements which have not been made; and were this course pursued, the work "On Mr. Spencer's Formula of Evolution," by Malcolm Guthrie, would disappear bodily. It is little else than a misstatement of certain fundamental views of mine, and then an elaborate refutation of the views as misstated.

Let me first show by brief extracts from "First Principles" what these views are. In a chapter on "Ultimate Scientific Ideas," after showing how the hypothesis that matter consists of solid atoms commits us to alternative impossibities of thought, I have shown how the hypothesis of Boscovich, that matter consists of centers of force without extension, is unthinkable. In the course of the argument I have pointed out that though Boscovich's hypothesis can not be realized in thought, yet, on the other hand, the hypothesis of extended atoms itself implies an imaginary separableness of each atom into parts, and again of these into parts, and so on without limit until unextended centers of force are reached: the consciousness of force being that which alone perpetually emerges. And I have ended by saying that

"matter, then, in its ultimate nature, is as absolutely incomprehensible as space and time." In the second part of the work, in chapters treating of "The Indestructibility of Matter," "The Continuity of Motion," and "The Persistence of Force," I have at some length elaborated the view that force is the ultimate component of thought into which our conceptions of external existences are resolvable. Summing up the first of these chapters, I have said, "Thus, then, by the indestructibility of matter, we really mean the indestructibility of the *force* with which matter affects us." At the close of the second of these chapters I have argued that "the continuity of motion, as well as the indestructibility of matter, is really known to us in terms of *force* ; . . . that which defies suppression in thought, is really the force which the motion indicates." And then in the third chapter, having shown how the truths that matter is indestructible and motion continuous, can be known to us only as corollaries from the truth that force is persistent —that force is that "out of which our conceptions of matter and motion are built"—I have gone on to say that, "by the persistence of force, we really mean the persistence of some power which transcends our knowledge and conception." Throughout all which arguments the implication is that I hold matter and motion to be conditioned manifestations of this unknown power. Being aware of the perversity of critics, I have, in the "Summary and Conclusion," again endeavored to bar out misinterpretation. Here is one of the sentences it contains: "Over and over again it has been shown in various ways that the deepest truths we can reach are simply statements of the widest uniformities in our experience of the relations of matter, motion, and force; and that matter, motion, and force are but symbols of the unknown reality. A power of which the nature remains for ever inconceivable, and to which no limits in time or space can be imagined, works in us certain effects. These effects have certain likenesses of kind, the most general of which we class together under the names of matter, motion, and force." In which sentences it is distinctly stated that I have throughout regarded matter, under the form present to consciousness, as a *symbol*—a certain conditioned *effect* wrought in us by the unknown power; and I have gone on to say that "the interpretation of all phenomena in terms of matter, motion, and force is nothing more than the reduction of our complex symbols of thought to the simplest symbols; and when the equation has been brought to its lowest terms the symbols remain symbols still."

It will scarcely be believed, and yet it is true, that notwithstanding all this Mr. Guthrie ascribes to me the vulgar conceptions of matter and motion; argues as though I really think they are in themselves what they seem to our consciousness; and proceeds to criticise my views on this assumption. He ignores the conspicuous fact that matter and motion are both regarded by me as modes of manifestation of force, and that force, as we are conscious of it when by our own efforts

we produce changes, is the correlative of that universal power which transcends consciousness. And then he ends the criticisms forming the second part of his work by saying, "If this is not materialistic I do not know what is." He does not do this by inadvertence, though there would be little excuse even then; but he does it deliberately and with his eyes open. His next chapter begins:

"It will have been observed that in the preceding part of this criticism I have employed the term 'matter in motion,' and have avoided the use of the word 'force,' although it appears so prominently in the pages of Mr. Spencer's work. This has not been accidental, but by design, indicating as it does one of my main criticisms of Mr. Spencer.

"I can logically take up one of two positions. The first recognizes matter, whose properties are merely those of extension, which are capable of being described in terms of geometry and arithmetic. I can also recognize as the sole active properties of matter its modes and rates of motion—the motion, that is to say, of ultimate units, atoms, molecules, or masses, also capable of measurement.

"The second position recognizes matter and its activity or activities—matter as endowed with force or forces."

Thus it will be observed that having avowedly dealt with matter and motion as modes of force, I am "by design" criticised as though I had not so dealt with them. Having distinctly said what I mean by matter and motion, I am practically told that I shall not mean that, but shall mean what Mr. Guthrie means; and shall be dealt with accordingly. And then, further, it will be observed that of the two positions which Mr. Guthrie lays down as possible, and proceeds to argue upon as alternatives, one or other of which I must accept, both speak of matter and units of matter as though actually existing under the forms thought by us; and the last, speaking of "matter as endowed with force or forces," implies that whether in mass or in units, matter is a space-occupying something which is in the one case inert and in the other case made active by force with which it is "endowed"—force which is added to the inert something. Spite of all the pains I have taken to show that I regard matter as *itself* a localized manifestation of force—spite of all the evidence that our idea of a unit of matter, or atom, is regarded by me simply as a symbol which the form of our thought obliges us to use, but which we can not suppose answers to the reality without committing ourselves to alternative impossibilities of thought, I am debited with the belief that matter actually consists "of space-occupying units, having shape and measurement." Though I have repeatedly made it clear that our ideas of matter, motion, and force are but the x, y, and z with which we work our equations, and formulate the various relations among phenomena in such way as to express their order in terms of x, y, and z—though I have shown that the realities for which x, y, and z stand can not be conceived by us as

actually existing thus or thus without committing ourselves to alternative absurdities; yet questions are put implying that I must hold one or other hypothesis concerning these actual existences, and I am supposed to be involved in all the difficulties which arise.

Another work devoted to the refutation of my views is that of Professor Birks—"Modern Physical Fatalism and the Doctrine of Evolution, including an Examination of Mr. H. Spencer's First Principles." Having dealt with the work of Mr. Guthrie, I can not pass by that of Professor Birks without raising the suspicion that I find some difficulty in dealing with it. Indeed, I do find a difficulty—a difficulty illustrated by that found in disentangling a skein of silk which has been pulled about by a child for half an hour. And just as the patience of a bystander would fail were he asked to look on until, by unraveling the tangled skein, its continuity was proved, so would the reader's attention be exhausted before I had rectified one tenth part of the meshes and knots into which Professor Birks has twisted my statements.

Abundant warrant for this assertion is furnished by the very first paragraph succeeding the one in which Professor Birks announces that he is about to take "First Principles" as representative of the "fatalistic theory." In this paragraph he represents me as asserting that ultimate religious ideas are "incapable of being conceived." He further says that ultimate scientific ideas are by me "pronounced equally inconceivable." Now, any clear-headed reader who accepted Professor Birks's version of my views would be led to debit me with the absurdity of saying that certain things which are put together in consciousness (ideas) can not be put together in consciousness (conceived). To conceive is to frame in thought; and as every idea is framed in thought, it is nonsense to say of any idea that it can not be conceived—nonsense which I have nowhere uttered. My statement is that "ultimate scientific ideas, then, are all representative of realities that can not be comprehended"; and the like is alleged of ultimate religious ideas. The things which I say can not be comprehended or conceived, are not the *ideas*, but the *realities* beyond consciousness for which the ideas in consciousness stand. In Professor Birks's statement, however, inconceivableness of the realities is transformed into inconceivableness of the answering ideas! Further, at the end of this first paragraph which deals with me, I am represented as teaching that religion "is equivalent to nescience or ignorance alone." This statement is as far removed from the truth as the others. I have argued at considerable length, and in such various ways that I thought it impossible to misunderstand me, that though the Power universally manifest to us through phenomena, alike in the surrounding world and in ourselves—the Power "in which we live and move and have our being"—is, and must ever remain, inscrutable; yet that the existence of this inscru-

table Power is the most certain of all truths. I have contended that while, to the intellectual consciousness, this Power, though unknowable in nature, must be ever present as existing, it must be, to the emotional consciousness, an object to the sentiment we call religious; since, in substance if not in form, it answers to the creating and sustaining Power toward which the religious sentiment is in other cases drawn out. Yet though in the most emphatic way I have represented this unknown and unknowable Power as the object-matter of religion, Professor Birks represents me as saying that the unknowableness of it is the object-matter of religion! Though I hold that an ultimate being, known with absolute certainty as existing, but of whose nature we are in ignorance, is the sphere for religious feeling, he says I hold that the ignorance alone is the sphere for religious feeling!

When in the first sixteen lines specifically treating of my views these three cases occur, it may be imagined what an intricate plexus of misrepresentations, misunderstandings, and perversions fills the three hundred and odd pages forming the volume. Especially may it be anticipated that the metaphysical discussions, occupying five chapters, are so confused that it is next to impossible to deal with them. I must limit myself to giving a sample or two from this part of the work: one of them illustrating Professor Birks's critical fairness, and the other his philosophic capacity.

In his chapter on "The Reality of Matter," he says (page 111), "The sense of reality in things around us, Mr. Spencer has truly said, is one which no metaphysical criticisms can shake in the least"; and the rest of the paragraph is devoted to enlarging upon this proposition. The next paragraph begins—"'Permanent possibilities of sensation' is merely an ingenious phrase, to disguise and conceal a self-contradiction": sundry antagonistic criticisms upon this phrase being appended. And then the opening words of the paragraph which succeeds are quoted from "First Principles." Now, since the refutation of my views is the aim of the work; and since both the preceding and succeeding passages specifically refer to my work; and since no other name is mentioned—every reader, not otherwise better instructed, will conclude that as a matter of course the phrase "permanent possibilities of sensation" is mine; and that the criticisms upon it tell against me. Even were there evidence that this phrase, "permanent possibilities of sensation," expressed, or harmonized with, a doctrine entertained by me; yet, as the phrase is not mine, the quoting it as mine would have been a literary misdemeanor. What, then, must be said of it when, instead of standing for any view of mine, it stands for an opposite view? Mr. Mill's expression, quoted by Professor Birks as though it were my expression, belongs to a theory of knowledge entirely at variance with that set forth and everywhere implied in "First Principles"; and a theory which, where the occasion was fit, I have persistently combated (see "Principles of Psychology,"

Part VII, "General Analysis"). And yet Professor Birks tacitly makes me responsible for the incongruities which result from uniting this theory with the opposed theory.

From this sample of critical truthfulness let us pass now to a sample of critical acumen.

In arguing against Hamilton and Mansell in § 26, I have said: "It is rigorously impossible to conceive that our knowledge is a knowledge of appearances only, without at the same time conceiving a reality of which they are appearances; for appearance without reality is unthinkable." On page 121 of his work, Professor Birks, quoting the last five words of this sentence, continues, "This is true, when once the conception of distance has been gained by actual experience." And he then proceeds to comment upon visual impressions, illusive and other. Again, on page 135, when criticising my argument concerning the indestructibility of matter, Professor Birks says: "Matter, as knowable, is declared to be not the unseen reality, but the sensible appearances, or phenomenal matter alone. Phenomenal matter, it appears from daily and hourly experience, appears and disappears, perishes and is new-created continually. . . . The cloud vanishes, the star sets, or a mist blots it out, the drop evaporates, the ship melts into the yeast of waves, the candle is burned away and comes to an end. The substance may last in another form, but the phenomenon or appearance is gone. . . . Thus, by the theory, of Matter, the Noumenon, we know nothing, and therefore can not know that it is indestructible. Of Matter, the Phenomenon, we may know much. And one main thing we know of it, proved by hourly experience, is that it both may be and continually is destroyed. For an appearance is destroyed and perishes, when it ceases to appear." In which sentences, as in all accompanying sentences covering several pages, the implication is that Professor Birks identifies appearance in the philosophical sense with appearance in the popular sense! Everywhere his expressions and arguments make manifest the fact that Professor Birks thinks the meaning of phenomenon in metaphysical discussion is no wider than that implied by its derivation—something visible! Sounds, smells, tastes are in his view not phenomena; nor are touches, pressures, tensions. And hence it results that since when a pound of salt is dissolved in water it ceases to be visible, its existence, phenomenally considered, ends: its continued power of affecting our senses by its weight, to the same extent as before the solution, not being considered as a phenomenal manifestation of its existence!

In § 46, when commenting on the mental confusion which metaphysical discussions often produce, I have ascribed this in part to the misleading connotations of the words "appearance" and "phenomenon"; and after illustrating this have said: "So that the implication of uncertainty has infected the very word *appearance*. Hence, philosophy, by giving it an extended meaning, leads us to think of all

our senses as deceiving us in the same way that the eyes do ; and so makes us feel ourselves floating in a world of phantasms. Had *phenomenon* and *appearance* no such misleading associations, little, if any, of this mental confusion would result. Or did we in place of them use the term *effect*, which is equally applicable to all impressions produced on consciousness through any of the senses, and which carries with it in thought the necessary correlative *cause*, with which it is equally real, we should be in little danger of falling into the insanities of idealism." This caution was intended for the general reader. That it might be needed by one who should undertake to deal with the work critically never occurred to me. Not only, however, does it seem that Professor Birks (who quotes the last three words of the paragraph) needs such a caution, but it further seems that the caution is thrown away upon him. For just those misinterpretations of the words above pointed out, are the misinterpretations he makes. After this I shall, I think, be absolved from examining further his metaphysical criticisms.

Of his criticisms upon various of the physical doctrines which this work contains, I will notice two only—the one because I wish to repudiate a view which, spite of abundant evidence to the contrary, he ascribes to me ; and the other, because, based as his statement is on a fact which he misinterprets, it is desirable to give the right interpretation of it. On page 188, Professor Birks says : "The essence of the doctrine held by Mr. Grove, Dr. Tyndall, and Mr. Spencer, and which the last has made the foundation of his whole theory of physical fatalism, is that there is, every moment, an unchanging total of force, which never varies in amount, while it incessantly changes its form. The force, then, which persists, must be a present existence. But potential energy is nothing of the kind. It is the sum of trillions of trillions of future possibilities of force, ranging through trillions of trillions of different future intervals of time." Now, the tacit implication here is, that I accept the doctrine of potential energy. The men of science named, with many others who might be added, hold that the total quantity of force remains constant. Against these it is urged that energy in becoming potential ceases to exist ; and that, therefore, the doctrine is untrue. And being represented as holding this doctrine in common with them, I am said to have based my general fabric of conclusions upon a fallacy. In the first place, I have to ask on what authority Professor Birks assumes that I hold the doctrine of potential energy in the way in which it is held by those named ? And in the second place, I have to ask how it happens that Professor Birks, elaborately criticising my views step by step, deliberately ignores the passages in which I have repudiated this doctrine ? In the chapter on "The Continuity of Motion" I have, at considerable length, given reasons for regarding the conception of potential energy as an illegitimate one, and have distinctly stated that I am at issue with scientific

friends on the matter. Devoting, as Professor Birks does, his chapter entitled "The Transformation of Force and Motion," to the incongruities which result when the doctrine of the persistence of force is joined with the doctrine of potential energy, as commonly received, it was doubtless convenient to assume, spite of the direct evidence to the contrary, that I accept this doctrine, and am implicated in all the consequences. But there can be but one opinion respecting the honesty of making the assumption. Let me add that my rejection of this doctrine is not without other warrant than my own. Since the issue of the last edition of this work, containing the passages I have referred to, Mr. James Croll, no mean authority as a mathematician and physicist, has published in the "Philosophical Magazine" for October, 1876, page 241, a paper in which he shows, I think conclusively, that the commonly accepted view of potential energy can not be sustained, but that energy invariably remains actual. I learn from him that he had in 1867 indicated briefly this same view.

The remaining case, above adverted to as calling for comment, concerns my motive for suppressing a certain passage in the chapter on "Ultimate Scientific Ideas," and substituting another passage. Before proceeding to state the reasons for this substitution, and to disprove the inferences which Professor Birks draws from it, I may remark that it is usual in literary criticism to judge an author by the latest expression of his views. It is commonly thought nothing but fair that if he has made an error (I say this hypothetically, for in this case I have no error to acknowledge), he should be allowed the benefit of any correction he makes. Professor Birks, however, apparently thinks that, moved by the high motive of "doing God service," he is warranted in taking the opposite course—perhaps thinks, indeed, that he would fail of his duty did any regard for generous dealing prevent him from making a point against an opponent of his creed.

But now, saying no more about the ethics of criticism, I pass to the substantial question. In the first place, I have to point out that in the passage suppressed I have not said that which Professor Birks alleges. He represents me as asserting that "gravitation is a necessary result of the laws of space" (p. 227). I have asserted no such thing. He says, "There can be no *a priori* necessity that every particle should act on every other at all at every distance" (p. 222). I have nowhere said, or even hinted, that there is any such *a priori* necessity. The notion that "gravitation results by a fatal necessity from the laws of space," which he ascribes to me (p. 229), is one which I should repudiate as utterly absurd, and one which is not in the remotest way implied by anything I have said. What I have said is that "light, heat, gravitation, and all central forces, vary inversely as the squares of the distances," and that "this law is not simply an empirical one, but one deducible mathematically from the relations of space." Now, what is here said to be "deducible mathematically from the rela-

tions of space"? Not a thing, or a force, but a *law*. What is the law here said to be knowable *a priori?* The *law of variation* of any or every central force. And what is alone included in the assertion of this *a priori* law? Simply this, that *given* a central force, and such is the law according to which it will vary. Nothing is alleged respecting the existence of any central force. Does Professor Birks contend that if I say that light, proceeding from a center, necessarily varies inversely as the square of the distance, I thereby say that the existence of light itself is known *a priori* as a result of space relations? When I assert that of the heat radiating in all directions from a point, the quantity falling on a given surface necessarily decreases as the square of the distance increases, do I thereby assert the necessary existence of the heat which conforms to this law? Why then do I, in asserting that the *law of variation* of gravity "results by a fatal necessity from the laws of space" simultaneously assert that "*gravitation* results by a fatal necessity from the laws of space"? Professor Birks, however, because I assert the first says I assert the second. My proposition, Central forces vary inversely as the squares of the distances, he actually transforms into the proposition, There is a cosmical force which varies inversely as the squares of the distances; and debiting me with the last as identical with the first, proceeds, after his manner, to debit me with various resulting absurdities.

Having thus shown that the passage in question contains no such statement as that which Professor Birks says it contains, I go on to show that I have not removed this passage because I have abandoned the belief it embodies. Clear proof is at hand. If Professor Birks will turn to the "Replies to Criticisms" contained in the third volume of my "Essays: Scientific, Political, and Speculative" (pp. 334–337), he will find that I have there defended the above proposition against a previous attack; and assigning, as I have done, justification for it, I have shown no sign of relinquishing it. Why, then, Professor Birks will ask, did I make the change in question? Had his mental attitude been other than it is, he might readily have divined the reason. Knowing, as he seemingly does, that this doctrine which he criticises had been already criticised in a similar manner (for otherwise he would scarcely have discovered the change I have made), he might have seen clearly enough that the passage was suppressed simply to deprive opponents of the opportunity of evading the general argument of the chapter by opening a side issue on a point not essential to its argument.

The chapter has for its subject, certain incapacities of the human mind—a subject, by the way, on which theologians are never tired of enlarging when it suits their own purpose, but on which an antagonist may not enlarge without exciting their anger. Various examples of these incapacities are given, to justify and enforce the conclusion drawn. Among these was originally included the example in ques-

tion. Misrepresenting it as Professor Birks misrepresents it, another writer had before him similarly based on his misrepresentation sundry animadversions. Though still regarding the statement I had actually made (not the one ascribed to me) as valid, I concluded that it would be best to remove the stumbling-block out of the way of future readers, and therefore decided to replace the illustration by another. The rest of the chapter remains exactly as it was, and its argument is not in the remotest degree affected by the substitution. Nevertheless, Professor Birks, wrongly describing the nature of the illustration, and wrongly attributing the removal of the illustration to change in my belief, also wrongly conveys the impression that the doctrine which the illustration contained had some vital connection with the general argument of the chapter and with the doctrine of the work; and by conveying this impression calls forth exultation from religious periodicals.

Were I to deal with Professor Birks's book page by page, a much larger book than his would be required to expose his misstatements, perversions, confusions. The above examples must suffice. I will add only that in one belief of his I cordially agree with him. At the close of his preface he says, "I think that those who take the pains to read my strictures, and compare them with the statements of the work to which they are a reply, will find the effort repaid by a clearer apprehension of the topics in debate." And I venture to join with this the expression of my belief that if readers follow Professor Birks's tacit suggestion, "a clearer apprehension of the topics in debate" will not result from acceptance of his criticisms.

LUBBOCK ON INSECT CONSERVATISM.

SIR JOHN LUBBOCK will certainly earn the praise of accumulating more facts upon which we may found reasonable inferences as to the intellectual character of the ant, than all his acute predecessors in the same field put together. And his latest published observations on the subject, communicated to the Linnæan Society, and printed in their "Transactions," contain some of his most interesting results. These results we should describe generally as showing that the ants display, first, a preternaturally keen sense of consanguinity; next, a good deal of that narrow conservatism which is so often the result of too much belief in the family and too little receptivity for the ideas of the external world; in the third place, a thorough distrust of revolution, so that they are almost equally afraid of establishing a new dynasty and of destroying an old one; and, finally, a good deal of the skepticism which narrow conservatism inevitably engenders toward all

suggestions not fitting easily into the established grooves. The ant, it is evident, does not, like Lord Beaconsfield, believe mainly in *race*, but, on the contrary, like the English squire, "acred up to his lips, consoled up to his chin," believes chiefly in family, and, we must add, has shown much more amazing instincts than any English squire in discriminating the progeny of one group of families from the progeny of another. That a strange ant, though of the same species, put into any nest, will be at once attacked and killed, Sir John Lubbock has proved again and again. Like the English rustic who, on assuring himself that a man is a stranger to the district, immediately proposes to "'eave 'alf a brick at him," the ants pay no regard to species at all, if they find an ant who can not trace his descent to their own nest intruding upon it. They make a principle of hostility to aliens, drawing no distinction between aliens of their own species and aliens of another species. But the remarkable thing appears to be their special instinct for identifying the descendants of their own tribe. Sir John Lubbock separated into two parts, in February, 1879, a nest of ants which contained two queens, giving about the same number of ants and one queen to each. In February the nest contains neither young nor eggs, so that the division was made before the earliest stage of being for the next generation began. In April both queens began to lay eggs. In July, Sir John Lubbock took a lot of pupæ from each division, and placed each lot on a separate glass, with attendants from the same division of the nest. At the end of August he took four previously marked ants from the pupæ bred in one division and put them into the second division, and one previously marked ant from the pupæ bred in the second division and put it into the first; in both cases the ants, which could never have been seen in any stage of their life by any of the ants in that division, were welcomed as friends, cleared of Sir John's paint, and accepted as members of the family. The same thing happened again and again. But whenever a stranger was introduced after the same fashion, it was immediately attacked and destroyed. This confirmed still more remarkably a series of less crucial experiments formerly made by Sir John Lubbock on the same subject. By some inscrutable sense or other, the ants, it is clear, know the descendants—at least in the first degree—of those which have once belonged to their own nest, even though they were neither born nor thought of when their parents left the nest. So much for the profound instinct of consanguinity in the ant, as well as for the unconquerable hostility they show to those ants who are not connected with them, within recognizable degrees at least, by blood.

But now as to the intense political conservatism which this bigoted sort of family feeling produces. Sir John Lubbock has discovered, it appears, that once let an ants' nest get accustomed to living without a queen—once let it organize democratic institutions—and nothing will induce it to admit a queen for the future. Queens introduced into

queenless nests were always ruthlessly killed, even though in one case Sir John exhibited the queen for three days to the ant-democracy in a wire cage which protected her from them, in order to accustom them to the sight of royalty. The moment the protecting wire was removed, the queen was attacked and slain, just as if she had been an ordinary alien. Sir John, however, was occasionally able, by the help of a little intrigue—of the Marshal MacMahon kind, but more successful—to obtain a throne for a wandering queen. The way he managed was this: He took a few ants from their nest, and put them, in that disorganized state, with a strange queen. The ants were then in a timorous and diffident mood. They had no fixed institutions to fall back upon. They felt wanderers in the world. And, feeling this, they did not attack the queen, but rather regarded her as the nucleus of a possible organization. By thus gradually adding a few ants at a time to a disorganized mob which had accepted the queen as the starting-point for a new polity, "I succeeded," says Sir John Lubbock, "in securing the throne for her." But this success speaks as much for the conservatism of the ants as the former unanimous rejection of the queen by an organized community. They repudiated a queen when they knew that their institutions were in working order without her. They accepted her, when they felt at sea and in peril of anarchy, as the germ of a new system. It was a timid conservatism which dictated their policy in each case. In the former, they rejected with horror the prospect of a change of constitution; in the latter, they accepted, not, perhaps, without eagerness, the prospect of a more rapid political development than, without any ready-made leader, they could have counted upon. For the ants, then, the throne was, as M. Thiers said of a republic, under dissimilar circumstances, the constitution "which divided them least."

And it is to be inferred, we think, that the languid skepticism which is one of the commonest causes or effects—it is difficult to say which—of that intense timidity which is so often connected with conservatism, affects these wonderful little creatures also. Sir John shows us most satisfactorily that the ants understand each other—that when an ant goes back from a bit of food which she is unable by her own strength to stir, she can and does communicate in some way to her fellow-ants the need of help. They clearly understand her message, and they prepare to assist her; but they have, it appears, no real confidence in her information. What they see with their own eyes fills them with the utmost eagerness, but what they learn from others they do not more than half believe. They usually go with the messenger, but they go without any real *élan*, without any of that earnestness which they display after getting personal experience of the existence of the store of food. After that they are all urgency. After that they outrun their fellows, and can not reach the store of provisions too soon. But on the hearing of the ear they act with the utmost languor.

They follow, but so slowly that they never keep up with their eager guide, soon drop behind, and generally give up the expedition, as one beyond their courage or strength, or at least too much for their half-faith. Let us hear Sir John's curious delineation of the sort of authority which one ant's information appears to carry to his fellow-ants :

"I selected a specimen of *Atta testaceo-pilosa*, belonging to a nest which I had brought back with me from Algeria. She was out hunting about six feet from home, and I placed before her a large dead blue-bottle fly, which she at once began to drag to the nest. I then pinned the fly to a piece of cork, in a small box, so that no ant could see the fly until she had climbed up the side of the box. The ant struggled, of course in vain, to move the fly. She pulled first in one direction and then in another, but, finding her efforts fruitless, she at length started off back to the nest empty-handed. At this time there were no ants coming out of the nest. Probably there were some few others out hunting, but for at least a quarter of an hour no ant had left the nest. My ant entered the nest, but did not remain there ; in less than a minute she emerged, accompanied by seven friends. I never saw so many come out of that nest together before. In her excitement the first ant soon distanced her companions, who took the matter with much *sang-froid*, and had all the appearance of having come out reluctantly, or as if they had been asleep and were only half awake. The first ant ran on ahead, going straight to the fly. The others followed slowly and with many meanderings ; so slowly, indeed, that for twenty minutes the first ant was alone at the fly, trying in every way to move it. Finding this still impossible, she again returned to the nest, not chancing to meet any of her friends by the way. Again she emerged in less than a minute with eight friends, and hurried on to the fly. They were even less energetic than the first party ; and, when they found they had lost sight of their guide, they one and all returned to the nest. In the mean time, several of the first detachment had found the fly, and one of them succeeded in detaching a leg, with which she returned in triumph to the nest, coming out again directly with four or five companions. These latter, with one exception, soon gave up the chase and returned to the nest. I do not think so much of this last case, because, as the ant carried in a substantial piece of booty in the shape of the fly's leg, it is not surprising that her friends should some of them accompany her on her return; but surely the other two cases indicate a distinct power of communication. Lest, however, it should be supposed that the result was accidental, I determined to try it again. Accordingly, on the following day I put another large dead fly before an ant belonging to the same nest, pinning it to a piece of cork as before. After trying in vain for ten minutes to move the fly, my ant started off home. At that time I could only see two other ants of that species outside the nest. Yet in a few seconds, considerably less than a minute, she emerged with no

less than twelve friends. As in the previous case, she ran on ahead, and they followed very slowly and by no means directly, taking, in fact, nearly half an hour to reach the fly. The first ant, after vainly laboring for about a quarter of an hour to move the fly, started off again to the nest. Meeting one of her friends on the way, she talked with her a little, then continued toward the nest, but, after going about a foot, changed her mind, and returned with her friend to the fly. After some minutes, during which two or three other ants came up, one of them detached a leg, which she carried off to the nest, coming out again almost immediately with six friends, one of whom, curiously enough, seemed to lead the way, tracing it, I presume, by scent. I then removed the pin, and they carried off the fly in triumph. Again, on June 15th, another ant belonging to the same nest had found a dead spider, about the same distance from the nest. I pinned down the spider as before. The ant did all in her power to move it; but after trying for twelve minutes, she went off to the nest. For a quarter of an hour no other ant had come out, but in some seconds she came out again with ten companions. As in the preceding case, they followed very leisurely. She ran on ahead, and worked at the spider for ten minutes; when, as none of her friends had arrived to her assistance, though they were wandering about evidently in search of something, she started back home again. In three quarters of a minute after entering the nest she reappeared, this time with fifteen friends, who came on somewhat more rapidly than the preceding batch, though still but slowly. By degrees, however, they all came up, and after most persevering efforts carried off the spider piecemeal. On July 7th I tried the same experiment with a soldier of *Pheidole megacephala*. She pulled at the fly for no less than fifty minutes, after which she went to the nest and brought five friends exactly as the *Atta* had done."

Can anything be more remarkable than the extraordinary difference in the demeanor of the ants taught by personal experience, and of the ants trusting to the report of another? Obviously, the latter had a very languid belief in the statements of their friends, just enough to make them enter on the enterprise, but not enough to make them prosecute it even so far as to hasten their pace in order to keep up with their eager friend. Clearly, the ants are not very good judges of character. Their predisposition to distrust sanguine statements, like the predisposition of timid conservatives in general, is so deep, that at the first obstacle they fall away, perhaps questioning the use of tasking themselves for news that sounds so improbable as that of a treasure-trove. Sir John Lubbock even reports one case in which a slave-ant, of the Polyergus species, twice returned to her nest in search of co-operation in vain. Nothing she could say would induce her fellow-slaves to enter on a new bit of work, without better evidence of its remunerative character than a wandering fellow-servant's report gave

them. Twice she returned alone to the unequal task, reproaching bitterly, no doubt, the faithlessness of her associates.

Those who doubt our reports of the extremely timid political caution of these insect tribes will convince themselves that we are not exaggerating if they will but refer to Sir John's very interesting account of these formican Conservatives—Tories they are not, for obviously there is no blatant element in the politics of the ants. Their democracy, when they are democrats, is the democracy of the Swiss Republic, not the democracy of the Imperialists, still less the democracy of the French Revolution.—*Spectator*.

DISTINCTIONS BETWEEN REAL AND APPARENT DEATH.

By Dr. WILLIAM FRASER.

A SATISFACTORY definition of life should express conditions involved in every phase of vital development, but never identified with any mode of inanimate existence. Transmutation represents one such fundamental distinction between animate and inanimate objects; for, although some inorganic combinations possess a degree of permutability consistent with substantial integrity, this in particular cases is always uniform in character and limited in extent. Ice, for example, may become successively changed into the liquid and gaseous state without chemical decomposition, but there is an intrinsic limit to such permutation, for under similar circumstances of pressure, at an unalterably fixed elevation of temperature, it invariably becomes resolved into simpler constituents.

There are apparently no such inherent restrictions to organic transmutations, which may be perpetuated indefinitely, under appropriate supplementary conditions, without perceptible intrinsic exhaustion. Yet organisms are never sufficiently independent to spontaneously evolve such progressive results, but require the constant accession of extrinsic energy to develop their included potentialities.

The sun is the physical source of extraneous energy for every species of vital change occurring on the earth's surface, as through the immediate agency of its rays vegetables are enabled to abstract from the surrounding medium those elements adapted to their special needs; and, although animals can not thus directly appropriate solar energy, yet they are enabled to utilize it by the assimilation of certain of these vegetable products which it has previously served to elaborate.

As all the progressive transmutations which indispensably constitute individual life are dependent on the constant incretion of material

energy, integration is also a universal concomitant of vitality, so that for practical purposes life may be provisionally defined as the continuous individual integration and differentiation of material energy.

While these two correlated processes pertain to every variety of life, the physiological expedients by which their respective activities are sustained must vary in conformity with the specific requirements of different structures. A simple unit of protoplasm effects all its vital purposes through direct interchange with its environment, without the necessity of any intermediate provision. But, in higher organisms, life is indissolubly associated with certain accessory processes, and, in these cases, though the molecular interactions on which its essential attributes immediately depend are directly imperceptible, yet it is possible to prove its existence or non-existence by sensibly demonstrating the presence or absence of these its inseparable concomitants.

Man with his powers unimpaired manifests his vitality in unmistakable terms, but conditions not incompatible with resuscitation may occur wherein all his functions are so reduced as to be directly imperceptible. In such cases, to prevent premature burial, it is important to discover some sign absolutely diagnostic of real or apparent death.

An essential characteristic of living bodies is their power of actively maintaining a degree of varying integrity of constitution in opposition to destructive influences. This requires the incorporation of extraneous materials and their conversion into definite specific structures, and always involves the immediate apposition of ingredients, as well as a reciprocal state of the parts to be nourished. Although such intimate reciprocation of living structures and nutrient materials must always exist, the means whereby it is effected varies exceedingly in different instances. In the lower order of beings it is accomplished very simply, the medium which they inhabit offering directly the requisite pabulum, which their own condition enables them to assimilate without any preparatory elaboration. In more complex organisms a definite correlation of parts is necessary to elaborate the crude materials of food, as well as to bring them into immediate relation with the various tissues.

In some simple forms vital action may be suspended indefinitely by desiccation, being restorable by moisture, and even in some higher cold-blooded animals a state of temporary negation may be induced by congelation, the vital powers returning concurrently with the absorption of heat. In man it is quite different: the animal functions may be suspended, and even some of the organic processes interrupted, without extinguishing life, but there are certain of his functions the cessation of which for a limited period must inevitably cause death.

As to their vital significance, man's functions may be classified into essential and supplemental—the former including such as can not be

discontinued beyond a brief interval without fatal consequences, the latter such as may be suspended or even destroyed without involving general dissolution. Thus, although sight is important to comfort, it may be lost without affecting vitality; the hepatic function may be vicariously performed; even the renal secretion may be suspended for a considerable period without death: but the complete cessation of any of the essential functions of circulation, innervation, or respiration must be speedily followed by such a result. By the circulatory forces, a constant flow of blood is directed to and from all the parts; by the nervous system, an alternating effect is produced on the tissue-elements, whereby at one time they assimilate, at another disintegrate; by the respiratory apparatus, certain of the resultant products are incessantly eliminated. These three complemental functions are so interdependent that the complete interruption of either necessarily leads to arrestment of all, and consequent death.

Human blood is of a highly complex nature, as through it the textures receive all the materials adequate to their continued maintenance and repair. Its chemical composition is never definite, varying in different individuals and in the same individual on different occasions. The relative uniformity, however, of some of its physical characters is indispensable to its vital efficiency. It is semi-solid, containing innumerable white and red corpuscles, the latter constituting nearly one half its mass. The absolute number of these corresponds with the degree of general vitality; their local aggregation fluctuates with varying contingencies.

This fluid is the seat of two distinct modes of motion—a sensible circulation through the heart and vessels, and a subtiler interchange with tissue-elements. Several causes conspire toward its circulatory mass-motion, the heart's action being a *sine qua non*. The molecular motions being invisible, an explanation of their *modus operandi* must be partly hypothetical. There are, however, certain associated phenomena admitting of direct observation under certain circumstances which serve to throw light on the physico-vital relations of the blood. Thus, besides its general distribution, it is subject to local variations in the total quantity of its mass, and in the relative proportion of its various constituents. As there are means of artificially exciting preternatural activity of the circulation to a recognizable extent, in parts open to observation, during the minimum degree of vitality, such a possibility affords a reliable method of infallibly deciding in any particular case as to the existence or non-existence of this vital process.

Tissues are divisible into vascular and non-vascular, according to the mode and extent of their nutritive supply. The latter, being destitute of capillaries, receive their nourishment from the neighboring vessels by endosmosis. The former are pervaded by those minute vessels, which admit red corpuscles in a lesser or greater number, ac-

cording to the degree of functional exaltation. The cutis vera being a superficial vascular tissue, the excessive accumulation of red corpuscles in its capillaries is readily perceived by the consequent floridity of surface. Such sensible reaction to direct irritation implies the concurrence of several determinate acts in the structures directly involved, as well as the coöperation of more remote parts. Thus the tissue-elements must possess a responsive power to become exalted in function, and to solicit a surplus of blood-ingredients they must also retain a continuity with the presiding nerve-center, whereby the peripheral impression may be centripetally transmitted along the afferent nerve to this point, thence reflected along the vaso-motor nerve, causing relaxation of the arteriolar muscles, enlargement of caliber, and a freer flow of blood into the part. Cardiac contractions are also necessary to propel the corpuscles into the capillaries, as the attraction of the tissue-elements for these minute bodies can act only at insensible distances.

Man's structure conceals the changes which occur within the minute blood-vessels, but some animals admit the examination of the interior processes which accompany and conduce to the external manifestations of capillary congestion. Observing the circulation in the web of the frog's foot under the microscope, fluctuations in its current are noticed independent of the heart's action. The corpuscles, perhaps flowing uniformly at first, may slacken their speed, then oscillate or even retrograde. Apply an irritant to the part, the flow soon increases, and a greater number of red corpuscles pass through in a given time; they also show a tendency to cohere as well as to adhere to the walls of the vessels, which may proceed so far as to choke up their caliber and prevent the transmission of blood. As the effect passes off, the corpuscles gradually separate, move on, and at length the circulation resumes its normal state. Such investigation explains the nature of the changes which occur in the capillaries of the human skin under artificial stimulation.

Heat, which is the most potent and available form of irritant, when applied to the skin so as to considerably elevate its temperature above the normal point, causes first an efflorescence of surface, deeper at the center and shading off gradually toward the circumference. This redness can be temporarily displaced, leaving a white impression, which disappears on removal of the pressure, the part resuming its floridity with a rapidity commensurate with the activity of the capillary circulation. By increasing the heat or prolonging its action the color becomes more distinct, till at the point of greatest intensity the cuticle becomes detached from its subjacent cutis by the gradual exudation and accumulation of a fluid which thus forms a true vesicle. A spurious vesicle may be similarly produced on the dead subject, but such is a purely physical and local effect, entirely different from the more comprehensive action and characters of the physiological process.

In *post-mortem* vesication the contents are generally gaseous from

decomposition, and even if fluid, from infiltration in an œdematous or dependent part, this is always serum, unlike the vital fibrino-albuminous solution coagulable by heat. The pathognomonic distinction, however, is the difference presented by the underlying cutis on removing the loosely adherent cuticle. This, after death, has an unalterable yellowish-white, crisp, horny appearance, in obvious contrast to the efflorescence of vital active congestion, which can be repeatedly displaced and renewed by recurrent pressure.

Although circulation is a vital necessity, the chemical products of its activity would of themselves speedily destroy life except for the concurrent exercise of the respiratory and other functions.

Tissues, such as the nervo-muscular, which perform some specific action, may be classed as active in contrast to passive, such as the osseo-fibrous, which merely subserve some mechanical office. When the ultimate particles of passive tissues are fully developed, they remain in that state for a longer or shorter period, and then gradually decay. Active tissues, during their development, appropriate a store of energy which, at maturity, they are capable of instantly expending in the manifestation of their special powers. Such exertions are inevitably attended by degradative transformations of their material elements. Cardiac movements and their associated vital coördinations involve the expenditure of nervo-muscular energy, and consequent production of simpler compounds, such as carbonic acid, the undue retention of which in the blood would cause certain death. Such a fatal contingency is prevented by the circulatory forces propelling the carbonized blood into the pulmonary capillaries, where an interchange with the oxygen of the air takes place through the intervening membrane till the vesicles become surcharged with carbonic acid, which is then expelled by the expiratory forces through the anterior openings of the air-passages, where its detention is evidence of vitality, while its utter absence under adequate tests is undeniable proof of the opposite condition. For, though certain cold-blooded animals can exhale a sufficient quantity of this product through their skin to permit a reduced vitality, in man such a cutaneous transpiration is exceedingly minute and altogether inadequate to the maintenance of life, and it may continue even after death as a merely physical property of tissue.

Innervation is blended with and controls all the vital operations, being conspicuously implicated with muscular contraction, an act primarily concerned in the various movements of respiration and circulation. The frequently-repeated transmission of intense electric currents is the most powerful stimulus of contractility, and, when such a measure fails to excite contraction in muscles essential to life, death must have occurred.

When rigidity and putrefaction are actually established, they may be accepted as infallible *post-mortem* indications. The former state arises from the muscles and other soft tissues becoming so stiffened as

to resist flexion of the joints, the muscles of the lower jaw and neck being generally first involved, those of the lower extremity last. It might possibly be confounded with stiffening from extreme cold or spasms; but frozen limbs yield a creaking noise when forcibly flexed, from breakage of the congealed moisture, and spasmodic contraction resumes its morbid position on removal of the correcting force. Not so *post-mortem* rigidity.

Putrefaction succeeds rigidity as a bluish-green tint of skin, commencing usually on the lower part of the abdomen and spreading over the body. Similar gangrenous appearances may occur during life, but, besides their more circumscribed extent, the invariable presence of a line of displaceable redness at the confines of the living tissues is a constant and characteristic distinction.

The desideratum, however, is some infallible proof of death whereby this state can at once be decided without waiting for the more tardy supervention of these positively *post-mortem* phenomena.

Neither the cadaveric aspect nor coldness and lividity of surface are constant or unequivocal signs. The cessation of the heart's action beyond five minutes is undoubted evidence, but it is impossible to acoustically determine this with absolute certainty, even when aided by the stethoscope, as the sense of hearing may be fallacious in delicate cases. Neither is the imperceptibility of the respiratory movements of the chest perfectly decisive. Conclusions from experiments on the eyes, by trying to excite the pupillary muscles by physiological agents, or by examining the fundus with the ophthalmoscope so as to observe certain changes supposed to be essentially *post-mortem*, are invalidated by the comparative unimportance of these organs to general vitality. The same uncertainty holds as to the effects produced by tightly ligaturing a limb, as there might be complete occlusion of its vessels and consequent arrest of its circulation without necessarily fatal results. The changes induced in a polished needle inserted deeply into the living tissues may be closely simulated by non-vital causes. Circumstances might also obscure the difference between the contents of vital and *post-mortem* vesication.

The possibility of absolutely deciding, in doubtful cases, as to the presence or absence of vitality depends on the possession of artificial means wherewith to sensibly demonstrate the minimum activity of each of the essentially vital processes, the utter negation of the various specific reactions under their appropriate tests being infallible evidence of death. The different available measures vary in their degree of simplicity and facility of application, but the results are all equally conclusive.

The validity of the respiratory test results from the fact that even during the most reduced state of vitality carbonic acid is perpetually generated in the system, and extricated therefrom through specially adapted air-passages, where its escape can invariably be detected by proper appliances.

Allowing a few hours to elapse after apparent death, so that an equilibrium may be established between the carbonic acid in the air-chambers and the atmospheric air, if death is real the amount of this product exhaled from the anterior opening of the air-passages will exactly correspond with that transpiring from an equal area of the skin; but, if the slightest vital action continues, the proportion thus expired in a given time will far exceed the whole cutaneous transpiration. Collecting it at its point of exit, by a suitable contrivance, into a small transparent vessel containing clear lime-water, its merest presence, in contrast to any other reagent, will change this fluid at once, on shaking, into an opaque, milky solution.

The innervation test is rendered practicable through the inseparable connection of this attribute with muscular contraction; for, even if contractility is inherent in muscle, its excitation is possible only through the incorporation of nerve-elements. As this manifestation of nervo-muscular energy can always be sensibly excited by electrification during the persistence of the feeblest vitality, the utter failure to obtain such a result in parts the activity of which is essential to life, affords conclusive evidence of vital extinction. The respiratory arrangements of the glottis present a favorable opportunity for prosecuting this special mode of experiment. At every inspiration the contractions of the associated muscles stretch and separate the vocal chords, thus, nearly doubling the area of aperture. In expiration the muscles relax, allowing the parts by their elasticity to resume their natural collapsed appearance. These changes can be observed by placing the body before a bright light, and introducing a laryngoscope well back into the pharynx, so as to bring the superior laryngeal aperture into view. After death the rima glottidis presents the elongated narrow form, from the close approximation of its chords. If, under the repeated transmission of intense electric currents, properly directed, there is no responsive contraction so as to sensibly widen the aperture, death is certain.

The circulatory test, or the attempt to excite an actively congested state of the cutaneous capillaries, is preëminently the best, as it requires only simple and easily procurable appliances, which always yield decisive results either in the living or dead subject. The application of heat and the act of cupping are both effective topical means for perceptibly arousing this preternatural activity of the cutaneous circulation, even in the most languid condition of the system compatible with vitality. The entire absence of such distinctive physiological reactions and the occurrence of merely physical alterations, under the proper use of these respective measures, is undeniable proof of death. Over the heart is the most suitable region whereon to operate, as there the skin longest retains its vital warmth; but corroborative experiments may be performed over other parts of the trunk.

Hold the flame of a candle close to (*but not in contact with*) the

skin sufficiently long to render the cuticle easily detachable from its subjacent connections: if the body is dead, the parts beneath will present a crisp, yellowish-white, horny appearance, unaffected by pressure; if alive, there will be readily perceptible a vital redness, distinguishable from all *post-mortem* discolorations by its repeated displacement and reappearance under alternating pressure by tip of the finger or otherwise. Exposing the part to a bright light, and examining it through a magnifying-glass, will render the different phenomena more evident.

Kindle a piece of paper soaked in any alcoholic liquor, put it in an ordinary drinking-glass or goblet, and invert this over a part of the cutaneous surface where all its edge will come into accurate contact with the skin: if there remains a minimum degree of vitality, a state of superficial capillary congestion will be induced, with its unmistakably recurrent characters; whereas the absolute inability to excite such vital reaction in any part of the trunk's surface, and the production of solely physical effects by such potent agencies, are infallible evidence that all vital correlations are irreparably destroyed.

SKETCH OF GENERAL ALBERT J. MYER.

GENERAL ALBERT J. MYER, extensively known as a meteorologist and the organizer of the United States and International Storm-Signal Service, was born at Newburgh-upon-Hudson, on the 20th of September, 1828. While still very young, his father removed to Buffalo. A maiden aunt took charge of the boy's education, and he early became a telegraph operator. Later, he went to school, and when sufficiently advanced entered Hobart College, Geneva. He graduated in 1847, and, having decided to study medicine, he went through the Buffalo Medical College, and obtained his degree of M. D. in 1851.

A predilection for military life impelled him to seek a field of usefulness for his surgical talents in the army, where he obtained a commission. He was ordered out upon the Plains, and it is said that one day, seeing some Comanche Indians waving their lances, the idea struck him that such motions might be utilized for army-signals, similar to those in use in the navy. The subject soon occupied a great deal of his attention, and, the more he thought about it, the more interesting it became to him, until finally he had invented an ingenious code of signals. The doctor's transformation into an inventor was noised abroad upon his return to the East, and the authorities, becoming interested in his idea, appointed a Signal Corps and placed him in command of it, and from 1858 to 1860 he was engaged in special duty, perfecting his system and educating his eighty-odd men in its use. In July, 1860, he was commissioned major, and made chief signal-officer

of the army. During the remainder of this year and until May, 1861, he was ordered to New Mexico and the Rocky Mountains by Secretary Floyd, for the purpose of giving his corps an opportunity to have actual practice in the field. On the breaking out of the war, Major Myer identified himself with the Union army. One of his lieutenants went over to the other side and succeeded in creating no little confusion, for with him he took a knowledge of the signal-service system, and it was not long before each army was able to read the signals of the other, so that constant changes in the key became necessary. He next served on General Butler's staff, at Fortress Monroe, and was General McClellan's chief signal-officer during the entire Peninsular campaign. In November, 1862, he took charge of the Signal-Office at Washington. Here he performed service which compelled recognition and remuneration at the hands of the Government, however unwillingly tendered, and he was brevetted as lieutenant-colonel for services at Hanover Court-House, colonel for services at Malvern Hill, and brigadier-general for "distinguished services in organizing, instructing, and commanding the Signal Corps of the army, and for its especial service October 5, 1864," when, by timely signals, were saved the post and garrison of Allatoona, Georgia.

It is said that General Myer was a strict disciplinarian, and exacting to the degree of intolerance. He had indomitable firmness, and it is possible that these traits of character may have been the causes why the overbearing Secretary of War, Mr. Stanton, took a dislike to him. But, whatever the causes, the Secretary's hatred took a violent form. When Myer was with Farragut before Mobile, he received an order, signed by Stanton, informing him that he was dropped out of the army on the ground that his appointment to the coloneley had not been confirmed. Myer then came on to Washington, took a house, appealed to the Senators and Congressmen, and fought the matter out till he was reëstablished. At the close of the war Colonel Myer began to turn his attention in the direction of meteorology, and to connect that science with the art of army signaling. The Smithsonian Institution had entered upon a system of taking weather observations in different parts of the country, and Colonel Myer began to work upon this basis, and more completely to elaborate a method of forecasting meteorological probabilities.

"In 1868 General Meyer published a 'Manual of Signals for the United States Army and Navy,' and about this time it was that his field of labor began to broaden and tend upward. By virtue of an act of Congress, approved February 9, 1870, he was charged with the special duties of observing and giving notice by telegraph and signals of the approach and force of storms on the Northern lakes and the sea-coast, at military posts in the interior, and other points in the States and Territories. He reorganized the meteorological division of the Signal-Office in June, 1871. By an act approved March 3, 1873, he

was placed in charge of special duties of telegraphy, etc., being authorized to establish signal-stations at lighthouses and life-saving stations wherever they might be convenient to his purposes. The training school at Fort Whipple, the signal-service drill, and the strict discipline of the weather corps, were all due to General Meyer's directing mind.

"From national observations it was quite in the natural order of things that General Myer's work should expand to international dimensions. The success of the United States Signal-Service Bureau excited the greatest interest abroad, and similar institutions were inaugurated in several of the European countries. Long before, General Myer had conceived the bold idea of a system of simultaneous observations in all parts of the Northern Hemisphere, and as soon as he could do so he pushed the matter onward, until in September, 1873, an International Congress was convened in Vienna, and he was sent there as the delegate from the United States. To this Congress General Myer proposed that 'it is desirable, with a view to their exchange, that at least one uniform observation, of such character as to be suited for the preparation of synoptic charts, be taken and recorded daily and simultaneously at as many stations as practicable throughout the world.' This proposition was unanimously adopted, and, as the delegates were virtually empowered to speak for their several countries, this vote assured the existence of the international system. From its very inception this system has proved a wonderful success, and now the following countries are taking simultaneous observations and exchanging them: Algiers, Australasia, Austria, Belgium, Central America, China, Denmark, France, Germany, Great Britain, Greece, Greenland, Iceland, India, Italy, Japan, Mexico, Morocco, the Netherlands, Norway, Portugal, Russia, Spain, Sweden, Switzerland, Tunis, Turkey, British North America, the United States, the Azores, Malta, Mauritius, the Sandwich Islands, South Africa, South America, and the West Indies.

"On the 1st of July, 1875, General Myer began to issue from the Army-Office at Washington the daily printed bulletin. July 1, 1878, the same office began to publish its daily international weather-map, which added to General Myer's triumphs. He also instituted a system of observations in ocean meteorology, simultaneous with the international observations. These have proved of immense value, and at present nearly a hundred observers are engaged therein. Thus the work has gone forward, constantly extending, constantly progressing in accuracy.

"General Myer paid a second visit to Europe last year, ostensibly for rest. At the request of the Italian Government, he gave valuable information concerning the system, and instead of a pleasure-trip this turned out a laborious one, and finally at Venice General Myer was prostrated by the trouble which eventually has caused his death.

"Like so many other men who have won eminent position through

their own efforts, General Myer was a victim of overwork. His field of labor was an ever-widening one, and his ambitious brain knew no discretion in the matter of rest, but pushed him onward beyond his powers of physical endurance. Once before, his ceaseless industry laid him low—at a time, too, by a curious yet characteristic chance, when he was supposed to be recuperating his energies in a foreign trip. In spite of this warning, which was certainly severe enough to be heeded, he refused to leave Washington this summer, and obtain the relaxation he so much needed, but kept at his post until he became so ill that he could not sign his name. Then he was obliged to leave at a time when, as it afterward proved, he had waited too long. He was brought to Buffalo, but instead of going to his beautiful summer home at Lake View, he took apartments in the Palace Hotel, Dr. Rochester, his family physician, taking charge of his case. His trouble was a painful complication of heart and kidney troubles, and, his blood becoming poisoned by the latter disease, he became delirious. In spite of the careful treatment and perfect nursing which he received he sank slowly and died, August 24th, at the early age of fifty-two, leaving a wife and six children.

"Although dying thus in the very height of his usefulness, and when he could ill be spared from his great work, General Myer lived to see his idea of an international signal-weather system in successful operation, and already sanctioned and supported by the leading nations of the Northern Hemisphere. His great idea has passed its experimental stage, and his friends have the satisfaction of knowing that competent and enthusiastic men will carry it forward to its fullest fruition. His legacy is a grand one, comprising an honest name, an heroic record, a stainless reputation both as soldier and citizen, the honor of an unpatented invention and application of telegraphy which materially helped to save the Union, and the glory of having originated one of the grandest ideas of the century—an idea the practical application of which has already saved many lives, and which is destined when more perfectly developed to work a revolution in the science of meteorology, and to banish, in part at least, that great cause of terrestrial waste—meteorological uncertainty.

"In appearance 'Old Probabilities' was a fine-looking, soldierly appearing man, with high forehead, firm mouth, and earnest, thoughtful eyes. He wore a short-cropped, full beard, and an abundant head of hair. His physiognomy indicated great decision of character and executive ability, and these signals from Nature's code were fully confirmed in his character and life."

We are indebted for the foregoing particulars of General Myer's career to an admirable sketch in the Buffalo "Daily Courier" of August 25th.

EDITOR'S TABLE.

THE NATIONAL ACADEMY OF SCIENCES.

THIS body held its November session in New York, and its meetings at Columbia College. In the absence of President William B. Rogers, Vice-President O. C. Marsh filled his chair. The proceedings were in a high degree interesting. It is commonly supposed that the disquisitions of this body belong to depths of profundity that are wholly unapproachable by ordinarily endowed mortals, but this is a quite erroneous view. There are often, to be sure, technical and mathematical papers intelligible only to those proficient in these subjects; but the principal topics considered at the recent meeting were not only of general interest, but they were so treated that well-instructed people could appreciate and enjoy them. The Academy, however, never bids for a crowd, and if there should be an influx of outsiders it would be immediately inferred that there is something wrong in the working of the association. Of the hundred members, thirty or forty usually get together at the meetings and devote themselves to reporting the results of research, and to the discussion of views presented. There are set papers, of course, but exposition is largely extemporaneous, and accompanied with blackboard and other illustrations.

The newspapers have given to the public notices of the main results of the late meeting, all of which will be more fully published in the "Transactions" of the Academy, or in the scientific periodicals. Among the novel and striking things brought forward was a new method of chemical analysis, by Dr. Wolcott Gibbs; Professor Rood's experiments in perfecting the vacuum; Professor Langley's researches into the distribution of heat in the spectrum, and his new method of measuring infinitesimal amounts of heat; Professor Henry Draper's photographs of the Orion nebula; and Professor Marsh's account of a fossil animal with an extra brain at the other end of the spinal column. The progress of the electric light was also critically discussed, and various other important subjects were duly considered. In short, if our friends the Academicians will pardon us, their meeting was a "complete success."

THE STUDY OF GREEK AT CAMBRIDGE.

WE drew attention, a year or two ago, to a movement in England, led by several head-masters of the public schools and other eminent gentlemen interested in education, to secure a relaxation in the university requirements regarding the study of Latin and Greek. The study of Greek was compulsory, and insisted upon as if it were the sole condition of turning out an educated man. A petition was sent to the authorities of Cambridge, asking that it be omitted if the student desired to take in its place a modern language. It was remarked that students entering the university "may be the peers of Airy and Adams in pure mathematics, of Tyndall and Huxley in natural science, of a Whewell and a Hamilton in moral science, but they must be able to read a play of Euripides and the Greek Testament, or Cambridge will not have them among its graduates." This state of things was such as to provoke decided protest on the part of liberal-minded men, and hence the public controversy upon the subject, and the petition that forced the issue upon the Cambridge authorities. A late number of the "Lancet" reports

progress on the question in the following paragraph: "A discussion took place in the Arts Schools at Cambridge on Tuesday, October 26th, on the report of an influential syndicate, which had been appointed to consider a memorial sent by schoolmasters and teachers, including the head-masters of Eaton, Winchester, Westminster, St. Paul's, Harrow, and Rugby—Matthew Arnold, C. Darwin, Sir J. Hooker, Professor Huxley, Professor Tyndall, Dr. Vaughan, and the Bishops of Exeter and Winchester. The memorial stated that 'the present regulations, according to which a knowledge of Greek is required from all candidates for the Previous Examination at Cambridge, have the effect of excluding a large and increasing number of able and deserving students from the benefits of university education,' and it respectfully prayed that the university would be pleased to take into consideration some means whereby candidates for an honor degree may be relieved from the obligation of passing an examination in Greek. After much deliberation and inquiry, the syndicate reported—1. In favor of the relaxation of the requirements of Greek in some cases; 2. That the relaxation should be restricted to candidates for honors; 3. That a knowledge of French and German should be accepted as a substitute for Greek."

But it seems that this reasonable report of the syndicate was not finally adopted. We learn from the London "Spectator" that the senate of the university decided against the petitioners by one hundred and eighty-five votes against one hundred and forty-five. The "Spectator" discusses this result in a way that is suggestive. It regrets the Cambridge decision, not from want of appreciation of Greek, but because the language is so poorly taught in the university. It declares that it heartily concurs in the following estimate of this study: "It is said that a knowledge of Greek is the only door of access to a certain plane of culture which contains more of the seeds of free life and intellectual energy than all the rest of the intellectual discipline of our schools put together. The genius of the Greek language and literature, it is said, is the genius of freedom. The genius of the Latin language is the genius of authority and law. We believe there is a great deal of truth in this view."

But no such ideal is realized in practice, and the actual results are thus stated: "The fact, no doubt, is that in the present embarrassing wealth of disciplinary studies a great many men, with a real gift for mathematics and physical science, and whose education at the university, so far as it is of any value at all, is carried through in the sphere of mathematics or physical science, take up Greek for the Previous Examination in the most perfunctory way, never attain even a rudimentary mastery of the language or the literature, and even lose something in the thoroughness of their early studies, by entering on a subject which they intend to drop as soon as ever it has answered their temporary purpose. Now, for such as these, the compulsory cramming of a little Greek—enough to enable them, perhaps, to construe decently a little New Testament or a little bit of the 'Anabasis' of Xenophon, after they have been carefully prepared by a tutor—is of no kind of good, and yet takes the place of an acquisition which might be of very real use to them in the career they actually propose to themselves." Again: "The real reason for regretting the decision of the University of Cambridge is the tendency of modern education toward superficiality. Whatever can be done to prevent subjects being taken up which are never to be pursued, and which are never so far followed out that they give those who have entered upon them a new sense of power, should be done. Whatever any university can do to en-

courage the *bona fide* study of Greek, it ought to do. There is no study so cultivating; there are few studies so humanizing; there are not very many studies so ennobling. But just for this reason we think but little of it as a mere whetstone for the understanding of boys; and think a very great deal, on the other hand, of the vast importance of not forcing on any one the necessity for a fragmentary acquisition which is to form no part of his future studies. Whatever else is necessary nowadays, this is most necessary—to prevent that dispersion of the mind over a hundred unconnected morsels of half-knowledge, to which the enormous multiplication of intellectual interests too much tends."

With this demand for thoroughness of study we entirely agree; and it favors the conclusion that of the multitude of subjects undertaken some must be cut off. We say, let those go that are demonstrated and acknowledged failures. The "Spectator's" complaint that Greek is superficially crammed at Cambridge, is but a fresh example of the lamentations of thoughtful men over the same result at the universities for two hundred years. It is not that modern science crowds classical studies so that there is not sufficient time. John Milton made exactly the same complaint when the dead languages and their literatures were almost the exclusive objects of university study, and there was no such thing as the rivalry of scientific studies.

When we consider the force of tradition in a conservative country like England, it is not to be expected that reforms in these rich old universities will move very fast; yet the majority for retaining the customary Greek was not large. Common sense makes headway, but the surprising thing is that the old extravagant claims for this study should still be urged. The "Spectator" affirms Greek to be the most cultivating of all studies, and among the very highest for its humanizing and ennobling influences. The authority of the "Spectator" is outweighed by those who declare that the influence of classical studies is of a very different character. Dr. Whewell characterized it as "narrow and enfeebling"; Macaulay says they have "a tendency to contract the views and deaden the sensibility"; and Sydney Smith speaks of the effect of classical learning as an "elegant imbecility." Certainly that can not be an eminently "cultivating" study which leaves whole important tracts of our mental nature uncultivated; nor can that be the most "humanizing" of studies which puts an ancient fraction of the human race, to be approached only through a dead language, in place of living humanity itself. And are we to regard that study as especially "ennobling" which knows nothing of the conquests, aspirations, and encouragements of the knowledge and life of the present time?

THE STUDY OF SEWERAGE IN LONDON.

The current standards of study and valuations of knowledge are factitious and false. Greek is not so ennobling a study as that of sewerage. To trace out the obscure laws of our own and of surrounding nature, so as to get command of natural agencies for beneficent ends, is the noblest object of study. If life be greater than any of its accidents, what study is so exalted as that which teaches how to save it, to improve it, and to perfect it? When diphtheria makes its dread appearance, and the priceless lives of beloved children are in mortal peril, then comes, with startling emphasis, the true answer to the question, "What knowledge is of most worth?"—it is the knowledge that leads to self-preservation. There is such a thing as life-saving knowledge, but it is not of the classical sort, nor that which is most prized in colleges, even in these later times. It is scien-

tific knowledge that teaches how life is to be protected and prolonged, disease prevented, health heightened, and human existence made more valuable. While at Cambridge they have been assiduous in conserving the more worthless kinds of knowledge and preventing thoroughness in any, in London men have been voluntarily combining to secure the more thorough application of scientific methods to household sanitation. Great multitudes die from unhealthy habitations. Their dwellings are poisoned by noxious emanations that give rise both to slow undermining maladies and to swift malignant diseases. Prominent among these destructive contaminations is sewer-gas, and science has at length grappled with the problem of getting effectually rid of it. It was at first supposed to be an easy task. "Traps" were interposed to prevent the refluence of sewage exhalations, and all was supposed to be well. But disease and death were still rife, and further investigation showed the inefficacy of the mechanical arrangements, and that "foul gases will pass steadily, continuously, and certainly through water in traps." Yet it can not be for a moment doubted that it is possible to obtain absolute protection in dwellings against sewer-air. The difficulty is to get the ignorant classes (including the educated) to give that serious attention to the subject which its gravity demands. The work must be done by the comparatively few who have mastered the science of the question.

Much has been accomplished by such men in this country as well as abroad. But we observe that they are organizing in London for the most effectual prosecution of this important work. A Sanitary Assurance Association has been formed under the presidency of an eminent physician, Sir Joseph Fayrer, the design of which is to unite the professions of medicine and architecture to secure the thorough supervision of sanitary arrangements and drainage in the houses of the metropolis. It seems not to be a movement of evasion by getting up a cry for more "government inspection," but a voluntary association of qualified men who are ready to meet the responsibilities of the task they undertake. Assuming that defective drainage is a "great enemy to public health," and that "there is a terrible absence of all supervision of sanitary arrangements," the Sanitary Assurance Association will make a careful investigation of the health-conditions of houses, and give certificates to those that are in perfect sanitary order. This will be of most important service to the public, because people generally are incompetent to determine what houses are healthy and what are unhealthy. The names of the men who are foremost in this movement are a guarantee that it will be well directed, and, if it achieves the success that it promises, kindred associations will spring up in many other places. A writer, giving a notice of this organization in "Nature," remarks: "It is surely as necessary to be assured against preventable diseases as it is to be assured against fire, and we see from the preliminary prospectus issued that it is intended to give persons who place their houses on the Assurance Register certificates that their houses are in a satisfactory sanitary condition, and to endorse such certificates from time to time; this latter point is of great importance, as it is only by regular inspection at stated intervals that it is possible to ascertain that all continues to work satisfactorily."

A FIELD-NATURALISTS' CLUB.

We have been much gratified in looking over a modest pamphlet of sixty-two pages that has been sent to us, bearing the title of "Transactions No. 1 of the Ottawa Field-Naturalists' Club." Several young men of that Canadian city, interested in the subject, discussed

for a year or two the possibility of starting a society devoted to the investigation of the natural history of the vicinity, and, having resolved to try it, they issued a few circulars, called a meeting, which was attended by some forty gentlemen, drew up a few rules, and established the association. The object is so praiseworthy, and the plan so well worth imitating in other places, that some account of the operations of this club may prove acceptable to many readers.

The club was organized by the appointment of a President, two Vice-Presidents, a Secretary-Treasurer, and a committee of five other members, all of whom are to constitute a Council of Management. Ladies and gentlemen desiring to join the club may become members by paying a fee of fifty cents a year. The club secures its objects by means of excursions in the summer for making observations and collecting specimens; and by holding evening meetings and *soirées* in the winter for reading papers, discussion, and exhibition, and the display and comparison of natural history objects, the general direction of these proceedings being vested in the Council.

The Council reports at the end of the first year that the work has gone on satisfactorily so as to afford every encouragement for continuing it. Large numbers, of course, do not take to such projects as this; and of those who do, or who join with entire good will, only a small portion have interest enough in the objects to be attained to discharge well the duties of membership. This is always to be counted upon in such undertakings, and should wisely moderate the expectations of the more sanguine. We are informed that the Council met twenty times during the year for the transaction of business, at irregular intervals, as occasion required; and at these meetings there was an average attendance of nearly seven out of nine of the Councilors. This certainly shows well, but the officers were of course picked for their interest in the work. The members were less dutiful. There were five excursions in the course of the summer to attractive points in the vicinity of Ottawa, but only a small part of the members accompanied them. This indifference is thus referred to in the annual report: "The Council feel compelled to express their regret that, although these excursions were to the most interesting places in the neighborhood, and the price of tickets put so low that three of them did not pay expenses, so few of the members thought them worth attending. It does not say much for the interest the members take in the club's work, that, with a membership of over eighty, the average attendance at the excursions should be only thirty, fully one third of whom were visitors; and they hope that during the coming season the excursions will be better supported by the members of the club."

But if the members did not care to go on the summer expeditions, they were less remiss when it came to the winter meetings. The winter course of *soirées* and *conversaziones* was successful in every respect. There was a well-sustained attendance, and the papers read were not only of considerable range but also of serious scientific interest. They were on the following subjects: 1. "Inaugural Address," on the pleasure of understanding common objects; 2. "Graphite of the Ottawa Valley"; 3. "On the Forms and Structures of some Spongillæ found in the Ottawa"; 4. "The Connection of Botany with Mythology"; 5. "Cystidian Life"; 6. "Museum Education"; 7. "On the Contractility of the Spores of Palmella Hyalina"; 8. "Asbestos"; 9. "A Practical Demonstration of the Human Brain"; 10. "Design in Nature"; 11. "Land and Fresh-water Shells of the Ottawa Valley"; 12. "On some Insects captured at our Excursions"; 13. "On some Plants collected during our

Excursions." Abstracts of these papers are given in the "Transactions," and they are of a very instructive character.

If we had space we would print the whole of the admirable "Inaugural Address," by Mr. James Fletcher, who happily remarks in his opening: "One of the chief benefits bestowed by an organization such as ours, is, that it enables one always to know where to find a sympathetic companion. Of all recreations, there is none, to my mind, more enjoyable than a walk in the country with a congenial friend. No kind of intercourse brings you into closer contact with a companion than taking a walk. You can not take ten steps, even with a stranger, without feeling a necessity of saying something, and, if there is anything in a man, you can soon bring it out of him in a country walk. Now, it is very clear that a judicious choice with regard to your companion is a most important matter; but it is not always easy to find one who has the same tastes or takes an interest in the same subjects as yourself. John Burroughs, in 'Winter Sunshine,' writes as follows: 'Professional walkers are very fastidious in choosing or admitting a companion, and hence the truth of a remark of Emerson that "you will generally fare better to take your dog than to invite your neighbor." Your cur dog is a true pedestrian; he enters into the spirit of the enterprise; he is not indifferent or preoccupied; he is constantly sniffing adventure; laps at every spring; looks upon every field or wood as a new world to be explored; is ever on some new trail; knows something important will happen a little farther on; whatever the spot, or whatever the road, he is always satisfied with it. In short, he is just that happy excursive vagabond that touches one at so many points, and whose human prototype in a companion, when such can be found, robs miles and leagues of half their power and fatigue.'

"The most interesting companion in anything is undoubtedly the one who can tell you most about it. Therefore, the best companion in the country must be a naturalist, who can point out objects of interest and explain their beauties and wonders. No one looks upon the world so kindly as he does; no one else gives so much attention to, or takes so much enjoyment from, the country as he does, and he holds a more vital relation to nature, because he is freer, and his mind is more at leisure. Moreover, when a naturalist gets a friend, who is not one, out in the country, he feels a sort of moral responsibility resting upon him to find something particularly interesting to point out, so as to arouse his curiosity, and, if possible, to convert him to the study of 'La Belle Science.' I say particularly interesting, because everything in nature is interesting and beautiful; and I defy any one to bring me a single object, picked up by a country roadside, which is not beautiful, and even exquisitely so—a stick, a piece of straw, a leaf, or a stone, it matters not what, if properly examined and understood, they are all wonderful and lovely."

As before remarked, we refer to the early experience of this club because it may afford guiding suggestions for the formation of similar associations elsewhere. In smaller towns there might not be found so many men cultivated in natural history to sustain such a society as in Ottawa, but that is not essential. In every village of five thousand inhabitants there is cultivated capacity enough, if it were combined, to carry on with some method and to valuable results the work of scientific self-improvement. It may be done to some extent anywhere, in many ways and with few facilities. All over the country there are individuals working alone and to great disadvantage; these would help others and be helped in turn by such combination and coöperation as might be almost everywhere

practicable. The high-school of every town ought to be the headquarters of a Field-Naturalists' Club that shall have for its object to study the natural history of the locality.

PHYSICAL EDUCATION.

It has not been our habit in this Monthly to make much parade about what we are *going* to do, being quite content with plain statements of what we *are* doing. In this spirit we ask attention to an important series of articles now begun on the subject of "Physical Education," and which may be expected to continue through the year. Dr. Oswald is widely known to the American public as a vigorous, thoroughly-informed thinker, and one of the most racy, incisive, and brilliant writers of the period. He will treat the subject from an original and especially modern point of view. It is a suggestive circumstance that in all modern languages the terms corresponding to what we call physical culture have acquired a specific meaning, being applied nearly exclusively to gymnastics and calisthenics as a branch of practical education. Yet the advocates of physical training in this limited sense were the first to take issue with the educational methods of the mediæval system—of the *anti-natural* school, as it has been justly termed, since its exponents ignored the physical interests of man as persistently as they denied his right to temporal happiness. The founders of the *Turn-bund*, like their Grecian prototypes, held that our highest physical and our highest moral well-being can only be conjointly attained; that health is the principal condition of happiness, and the normal condition of all whose mode of life is not grossly at variance with the simple laws which Nature proclaims in the unmistakable language of our instincts.

These principles Dr. Oswald has applied to the science of *Physical Education* in the widest sense of the word. The serial will comprise an exposition of "Dietetics," the first installment of which is herewith issued, to be followed by chapters on "In-door Life," "Out-door Life," "Gymnastics," "Hereditary Influences," "Clothing," "Remedial Education," etc.

Dr. Oswald has studied the social conditions and sanitary habits of many communities, having traveled in Mexico, South America, and Southern Europe, so that his articles will be enriched with the results of wide and careful personal observation; and it will be found that the author has solved the problem of making a scientific work as attractive to the most fastidious amateur of *belles-lettres* as to the scientific reader and the public in general.

LITERARY NOTICES.

The Atomic Theory. By Charles Adolph Wurtz, Member of the French Institute. Translated by E. Cleminshaw, F. C. S. New York: D. Appleton & Co. Pp. 344. Price, $1.50.

There is a certain sense in which the modern atomic theory may be regarded as the realization of a dream or the fulfillment of a prophecy, or, still better, the verification of a shrewd guess inspired by common reflection and common sense. The notion of matter being all made up of infinitely small particles or atoms was a speculation of the ancient Greek philosophers which has been revived in modern times, and during the present century has become established as a fundamental theory of chemical and physical science. The atomic theory has now assumed a definite form, and binds into unity wide ranges of facts so as to afford a consistent and intelligible view of the constitution of material things. It has been a subject of acute, profound, and protracted controversy, but has grown in clearness and strength with time, as our experimental knowledge of matter has been gradually extended. The most subtle attacks upon it have generally resulted in confirming it, and it has been an instrument of progress even in the hands of those who have doubt-

ed it as an expression of a basal truth in nature. The history of the growth of this conception consequently forms one of the most interesting chapters in the development of scientific ideas; while an exposition of its principles affords the completest exemplification of the views now entertained of the structural and constitutive laws of matter.

All books upon chemistry are now to a certain extent treatises upon the atomic theory, which becomes more and more indispensable as this science increases in extent and complication. The latest phase of chemical progress—the "New Chemistry," as it is called—is entirely pervaded by atomic and molecular theories, while molecular physics is now more completely coordinated with chemistry through the intervention of the atomic hypothesis than has ever been possible before. So important has this idea become, that special treatises are required to deal with it. The "New Chemistry" of Professor Cooke is one of the ablest of these expositions, and has done a most valuable service to education by facilitating the mental transition from an old to a new order of ideas.

Yet the subject is one of so many aspects and such deep and comprehensive significance that it can not be exhausted in any single treatise. There was need for a book like this of Professor Wurtz, which discusses the atomic theory both in its historic evolution and in its present form, with the view of bringing out clearly the influence it has exercised upon the progress of science since the beginning of the century. And perhaps no other man of this age could have been selected so able to perform the task in a masterly way as the illustrious French chemist who contributed the present volume to the "International Scientific Series." He gave himself early to chemistry, and became chief of the chemical department in the Medical Faculty at Strasburg, at the age of twenty-two. He was soon after called to Paris, and became at once connected with its great scientific institutions. After the death of the celebrated toxicologist Orfila, in 1853, and the retirement of Dumas in 1854, their chairs were united in that of Medical Chemistry and given to Wurtz. In 1867 he became a member of the French Academy of Sciences, which had previously awarded him a prize of twenty thousand francs. He has written much upon chemistry, pure and applied, and has paid great attention to the history of chemical doctrines. Among English translations of his works are, "Chemical Philosophy, according to Modern Theories" (1867), and "Theory from the Age of Lavoisier" (1869). "The Atomic Theory" is his last and crowning work, and it has a special authority derived from its author's critical study of chemical progress in the present century.

It is impossible to convey to the reader, in a notice like this, any adequate idea of the scope, lucid instructiveness, and scientific interest of Professor Wurtz's book. The modern problems of chemistry, which are commonly so obscure from imperfect exposition, are here made wonderfully clear and attractive. The statements are sufficiently full without being overdone, the writer's object being simply to make the reader understand the topic that is treated. Many passages might be quoted; here is the account of the "vortex theory," taken from the final chapter of hypothesis upon "The Constitution of Matter":

> In these later times a theory has arisen which seems to give a mathematical demonstration, and even an experimental illustration, of the indivisibility, or rather of the peculiar and eternal individuality, of atoms: I refer to the vortex atoms of Sir William Thomson.
>
> Chemists can form an idea of this vortex motion by recalling to mind the rings which rise in still air whenever a bubble of phosphoretted hydrogen bursts upon the surface of water, and the rings which certain smokers are able to make are familiar to all. An apparatus has been constructed by which they may be produced at will. It is a wooden box, one side of which is furnished with a circular opening, and the other formed of a tightly stretched cloth. In the interior of the box fumes of sal-ammoniac are produced, which are driven out by a sharp blow on the elastic side. A ring of smoke is then seen to issue from the opening, and to move freely through the room. In this ring all is motion, and, independently of the motion of translation, the smoke-particles roll over each other and execute a rotary motion in every section of the ring. These motions take place from the interior toward the exterior of the ring, in the direction of the motion of translation, so that the entire mass of air, or of the smoke which forms the ring, revolves continually round a circular axis, which forms, as it were, the nucleus of the ring. There is this remarkable fact in this rotary motion, that all the particles which

are situated upon one of the curves which can be drawn in each section of the ring, are indissolubly tied down to their circular paths, and can never quit them; so that the whole mass of the vortex ring will be always formed of the same particles. This theorem was proved by Helmholtz in 1858. This eminent physicist has analyzed the vortex motions which would exist in a perfect fluid free from all friction. He has proved that in such a medium vortex rings, bounded by a system of vortex lines,* are formed of an invariable quantity of the same liquid molecules, so that the rings can move, and even change their form, without the connection of their constituent parts ever being broken. They will continue to revolve, and nothing will be able to separate them, divide them, or destroy them. Those existing in the liquid will exist there for ever, and new ones can only be excited in it by a creative act.

The smoke-rings, of which we have spoken above, would give a perfect representation of these liquid vortex rings if they were formed and moved in a perfect fluid. They are not so; but such as can be formed can serve for the demonstration of some properties of matter in vortex motion. They are endowed with elasticity and can change their form. The circle is their position of equilibrium, and, when their form is altered, they oscillate round this position, and finally reassume the circular form. But, if we try to cut them, they recede before the knife, or bend round it, without allowing themselves to be injured. They give, therefore, a representation of something which would be indivisible. And when two rings meet each other, they behave like two solid elastic bodies; after the impact they vibrate energetically. It is a singular fact that when two rings are moving in the same direction, so that their centers are situated upon the same line, and their planes perpendicular to this line, the hinder ring contracts continually, while its velocity increases; the ring in advance, on the contrary, expands, and its velocity decreases until the other has passed it, when the same action recommences, so that the rings alternately pass through each other. But, through all these changes of form and velocity, each preserves its own individuality, and these two circular masses of smoke move through the air as if they were something perfectly distinct and independent. These curious experiments were made in England.†

Helmholtz, therefore, has discovered the fundamental properties of matter in vortex motion, and Sir William Thomson has stated, "This perfect medium and these vortex rings which move through it, represent the universe." A fluid fills all space, and what we call matter are portions of this fluid which are animated with vortex motion. There are innumerable legions of very small fractions or portions, but each of these portions is perfectly limited, distinct from the entire mass, and distinct from all others, not only in its own substance, but in its mass and its mode of motion—qualities which it will preserve for ever. These portions are atoms. In the perfect medium which contains them all, none of them can change or disappear, none of them can be formed spontaneously. Everywhere atoms of the same kind are constituted after the same fashion, and are endowed with the same properties. It is well known, in fact, that the atoms of hydrogen vibrate exactly in the same periods, whether we heat them in a Geissler's tube, observe them in the sun, or in the most distant nebulæ.

Such is, in a few words, the conception of vortex atoms. It accounts, in a satisfactory manner, for some properties of matter, and of all the hypotheses upon the nature of atoms it appears to be the most probable. We see also that it permits the revival of the ancient hypothesis of the unity of matter, and in a more acceptable form than that of Prout's hypothesis. Is the idea absolutely new? No; it was originally conceived by Descartes. So far is it true that, when the perpetual, and perhaps insolvable, problem of the constitution of matter is discussed, the human mind seems to turn in a circle, the same ideas lasting for ages, and being presented under fresh forms to the highest intellects who have endeavored to solve this problem But is there no difference among these great intellects in their manner of working? Most certainly: some, more powerful, perhaps, but bolder, have proceeded by intuition; others, better armed and stricter, by induction. Here lies the progress and the superiority of modern methods, and it would be unjust to pretend that the important efforts, of which we have had striking testimony, have not made an advance in this difficult problem which was impossible to Lucretius and even to Descartes.

* "Wirbelfäden und Wirbellinien."

† P. G. Tait. "Lectures on some Recent Advances in Physical Science." London, 1876.

The Skin in Health and Disease. By L. Duncan Bulkley, M. D. Philadelphia: Presley Blakiston. Pp. 148. Price, 50 cents.

We have here an excellent contribution to the series of "American Health Primers." It is as good as its predecessors, which is no slight praise. There are many popular books on that important subject, "The Skin," and several of them meritorious, but this is no reason why Dr. Bulkley should not have made another—because, in the first place, this interesting organ of the body is very important in relation to health, and there are but few people who are at all aware of it. They have not only to be taught, but the lessons must be hammered into them by ceaseless repetition. Hence the need of fresh and unremitting inculcations. Dr. Bulkley's book is to be welcomed on this ground; but it has also a special merit which we have

not before observed in popular skin treatises, and which gives it a special claim upon intelligent readers. It is not only a guide for the preservation of the health of the skin, but it is a kind of medical dictionary on the subject, giving important information which kindred books omit. This feature of the work is thus explained in the author's prefatory note: "He has therefore sought to introduce in its pages not only the medical terms used in reference to diseases of the skin, but also the popular names given, both those which are rightly and those which are wrongly applied. If, therefore, information be sought in reference to any particular matter, it will be well first to consult the index, which has been made particularly full."

A Text-Book of the Physiological Chemistry of the Animal Body. Including an Account of the Chemical Changes occurring in Disease. By Arthur Gamgee, M. D., F. R. S., Professor of Physiology in the Owens College. With Illustrations. Vol. V. Pp. 487. Macmillan & Co. Price, $4.50.

This elaborate work will prove most acceptable to the interested students of physiological and medical chemistry. The activity of research in these departments is very great; thoroughly equipped experimental laboratories are multiplying in different countries, and trained men are concentrating their efforts more and more upon special lines of inquiry. The consequence is, a rapid revision of former results, an extension of observations, and a noteworthy physiological progress. Dr. Gamgee's book is written from the point of view, not of former text-books, but of the latest original memoirs, which are continually referred to, and from the point of view of his own varied and laborious experimental investigations. The volume forms a complete and independent work, though it is intended to be followed by another within a year. It is devoted mainly to the elementary tissues or substances of the body—blood, lymph, and chyle being included in the classification—and it deals with the chemical composition, changes, and processes of these parts. The second volume will treat of the chemistry of the chief animal functions. In the method of the work physiological chemistry has been regarded from the point of view of the biologist and the physician rather than from that of the chemist. In this respect the book deviates widely from the typical plan of works on organic chemistry, where the dominant and classifying conceptions are of the chemical order. The volume will meet a want and be much appreciated as a high-class text-book, and it may be safely consulted by all interested in fundamental chemico-physiological questions.

A Physical Treatise on Electricity and Magnetism. By J. E. H. Gordon, B. A., C. A. M. B., Assistant Secretary of the British Association. In Two Volumes. Pp. 618. D. Appleton & Co. Price, $7.

Of all sciences that of electricity is perhaps the most purely experimental. The agency has always to be evoked by special manipulation. While the properties of heat have always been more or less known to everybody, nothing was known of electricity for thousands of years. It was a revelation that followed the art of experimenting, and it has advanced at a rate exactly proportioned to the progress of experimental art.

Mr. Gordon in this new work has dealt with the science entirely from this side, limiting his use of mathematics, except in a few foot-notes and appendices, to simple algebraic operations. The work is issued in two beautifully printed volumes, which are profusely illustrated with finely executed engravings, representing the present perfection of electrical apparatus and the refinements of electrical processes, and, besides a clear and concise statement of the main facts of the science, contains an exposition of many of the more recent and important experimental researches.

The author claims that he has aimed throughout to interpret the various phenomena in accordance with the theory worked out mathematically by Maxwell and others, which regards inductive influence as transmitted by strain or vibrations of some kind in the intervening medium, instead of being a direct "action at a distance." In accordance with this purpose, most of the later researches to which attention is particularly given, are those which directly bear upon problems the solution of which will throw light upon what may be termed the mechanism of electrical action. Though not

a popular work, the matter is presented in a manner to be of interest to others than professed students of the science, and should be read by those who desire to know something of the methods and appliances of experimental research in this branch of knowledge.

The subject is considered under the four general divisions of electro-statics, magnetism, electro-kinetics, and electro-optics. Of the first division, a large portion is devoted to the researches of various investigators, including the author, upon the specific inductive capacity of different insulating substances. The subject has important practical as well as theoretical bearings, for upon the low specific inductive capacity of the insulating material used in telegraph cables and wires depends the completeness of the insulation. It is important theoretically, as furnishing evidence by which to test the truth of the theory that induction is transmitted by strain in a continuous medium, as this requires certain relations between the specific inductive capacities and the refractive indices of transparent non-conductors. The work involved is one of considerable difficulty, and though many able experimenters have occupied themselves with the problem, the results obtained differ widely. Mr. Gordon's chapter is a very full presentation of all that has been done, and is one of the most valuable in the work. Besides this investigation, this division contains a clear and complete description of the electrometer of Sir William Thomson, supplemented with a number of drawings of the entire instrument and its various parts.

In the portion of the work devoted to magnetism, descriptions and illustrations of the best modern instruments for measuring magnetic elements—the Kew unifilar magnetometer and dip-circle, and the dip-circle of Mr. Fox for use at sea—are given, with the full instructions for their use. Electro-kinematics includes the various phenomena of voltaic electricity and electro-magnetism, and contains accounts of a number of important and difficult researches. Among these are the determination of the British Association unit of electrical resistance in absolute measure, Blaserne's experiments upon the extra currents, and the investigations of Faraday, Verdet, Weber, and Tyndall upon diamagnetism. A very full and complete description is given of the researches upon the discharge of the electric spark in different gases and at various pressures, and especially of De la Rue and Müller and Spottiswood upon the character of the discharge in high vacua, and the remarkable investigations of Mr. Crookes upon radiant matter. The experimental inquiries of Ayrton and Perry on the difference of potential produced by the contact of dissimilar metals, in elucidation of the question of the origin of electro-motive force in a battery, are also very fully considered.

The division of electro-optics is concerned with a class of important phenomena touching the relation of electricity and light. A full account is given of the discovery by Faraday of the rotation of a beam of polarized light in a magnetic field; and the further researches of Verdet, Becquerel, Kündt, Röntgen, Dr. Kerr, and the author. Mr. Gordon closes his work with a brief sketch of the electro-magnetic theory of light of the late Professor Maxwell, which he states to be that "electro-magnetic induction is propagated through space by strains or vibrations of the same ether which conveys the light-vibrations, or, in other words, 'light itself is an electro-magnetic disturbance.'" The evidence in favor of the theory is found in the similarity in the mode of propagation of both influences, the approximate equality of their velocity of transmission through space, and in the character of conductors. Light-vibrations are at right angles to the line of propagation, and this condition is shown mathematically to hold in the case of induction. The theory requires good conductors to be opaque, which as a fact they are. The most important evidence that both light and induction are transmitted by the same ether is, however, found in the fact determined experimentally that they both have sensibly the same velocity in air and a vacuum. The theory might well bear a fuller exposition than Mr. Gordon has made, and many readers will regret that he has not set it forth at greater length.

School and Industrial Hygiene. By D. F. Lincoln, M.D. "American Health Primers." Philadelphia: Presley Blakiston. Pp. 156. Price, 50 cents.

We cordially welcome these cheap, use-

ful manuals on topics of vital moment to the people, but the danger is that they will be too much cheapened, and become inadequate to the ends they propose. In the present case we think a mistake has been committed in dividing this book into two parts, the first treating of "School Hygiene," and the second of "Industrial Hygiene." These topics are too large and too momentous to be both dispatched in a fifty-cent primer. The author has done as well as he could with the subjects in the space assigned, and the book undoubtedly contains a good deal of important information well presented. The first part, comprising 106 pages, is much the best, but it would have been still better if he had devoted the other fifty pages to the same subject; various points that he has treated should have been much more amplified, and "Industrial Hygiene" dealt with in a separate book.

The Ocean as a Health-Resort: A Hand-book of Practical Information as to Sea-Voyages for the Use of Tourists and Invalids. By William S. Wilson, L. R. C. P. Philadelphia: Presley Blakiston. Pp. 260. Price, $2.50.

In this age of restlessness, when "everybody goes to Europe," and the trip around the world is becoming commonplace, a special book on the requirements and experiences of sea-travel and its hygienic influence may be useful to a large number of persons. To the unpracticed traveler a first sea-voyage is generally a very uncomfortable experience. Aside from sea-sickness, there are many more inconveniences and disagreeablenesses than are compensated for by the novelty of the situation; and, if a person is out of health, these effects are naturally aggravated. The author of this book assumes that there would be a great mitigation of sea-troubles if there was more information about them to guide the traveler; and so he has attempted to bring together various hints, explanations, and practical directions by which sea-life may be made most comfortable. He gives instruction as to the outfit, and what is to be expected in the way of accommodation, food, and amusement in long voyages. The diseases to which sea-voyages are supposed to be favorable are considered, and the various curative effects of the ocean-climate. The most suitable routes for particular hygienic objects are pointed out, and the choice of ships and the best times of the year for voyaging are also noticed. There are chapters on the "Management of the Health at Sea," on "Occupations and Amusements at Sea," on "Objects of Interest at Sea," and on "The Meteorology of the Ocean." The book is English, and the author assumes the voyage to Australia by the Atlantic route to be, on account of its length and many advantages for invalids, the typical health-voyage; but he gives many particulars concerning various other sea-routes, so that those inclined to ocean-travel can have a choice of courses, and make their preparations accordingly. The volume is well worth consulting before going to sea, and, as it is not large, it may be found profitable to take it along.

The Philosophy of Mathematics, with Special Reference to the Elements of Geometry and the Infinitesimal Method. By Albert Taylor Bledsoe, LL. D. Philadelphia: J. B. Lippincott & Co. Pp. 248.

This work appeared several years ago, but its discussion of mathematical questions is of permanent interest. It is not a general philosophy of mathematics, such as might be based upon the historical development of mathematical conceptions, but it is limited to the higher mathematics, and is a critical inquiry into certain controverted questions which have long exercised the ingenuity of the learned. One of the main objects of the book is to combat the idea that the circle is to be regarded as but a regular polygon of an infinite number of sides. The book abounds in mathematical erudition, and has much interest for the devoted cultivators of the science.

The Orthoëpist: A Pronouncing Manual. By Alfred Ayres. New York: D. Appleton & Co. 1880. Pp. 207. Price, $1.

The author has in this manual given the pronunciation, as determined by the best usage, of a large number of English words that are frequently mispronounced. The list contains about thirty-five hundred words, and includes the more commonly used foreign ones. The recognized authorities are cited in support of the pronunciation given, and when they differ the preponderant opin-

ion is indicated. When the author inclines to a pronunciation differing from the received one, what he regards as sufficient reasons are given for the preference. The book is in compact form, and will be found a very desirable one to have at hand.

What to do first in Accidents or Poisoning. By Charles W. Dallas, M. D. Philadelphia: Presley Blakiston. Pp. 68. Price, 50 cents.

This is a brief but well-digested manual of directions as to what to do in accidental emergencies that are liable to happen to everybody. It is extremely brief, but pointed and practical.

PUBLICATIONS RECEIVED.

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The Feeling of Effort. By William James, M. D. Published by the Boston Society of Natural History. 1880. Pp. 32.

The Electric Laryngoscope. By A. Wellington Adams, M. D. Reprinted from "Archives of Laryngology." Pp. 5.

Thirty-seventh Annual Report of the New York Association for Improving the Condition of the Poor for the Year 1880. Pp. 47.

Hollow Brick. Solution of Equations and Interpolation in Series; Foundations; Arches in Masonry and Bridges. Washington: Government Printing-Office. 1880. Pp. 33. Illustrated.

Higher Education of Medical Men. By F. D. Lente. M. D. New York: C. L. Bermingham & Co. 1880. Pp. 16.

Current Views and Notes of Forty Days in France and England. By John Swinton. New York: G. W. Carleton & Co. 1880. Pp. 45. 25 cts.

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On the Identity of the Ascending Process of the Astragalus in Birds with the Intermedium. By Professor Edward S. Morse. Published by the Boston Society of Natural History. 1880. Pp. 10. Illustrated.

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Ontology. By Emanuel Swedenborg. Translated by Philip B. Cabell. A. M. Philadelphia: J. B. Lippincott & Co. 1880. Pp. 40.

The Geology of Hudson County, New Jersey. By Israel C. Russell. From the "Annals of the New York Academy of Sciences." Pp. 53. Illustrated.

The Relations of Science to Modern Life. By Henry C. Potter, D. D. New York: G. P. Putnam's Sons. 1880. Pp. 29.

Telegraphic Measurement of Differences of Longitude by Officers of the U. S. Navy, 1878 and 1879. Washington. 1880. Pp. 87. Illustrated.

Report on the Geology of the High Plateaus of Utah, with Atlas. By C. E. Dutton. Washington: Government Printing-Office. 1880. Pp. 307. Illustrated.

The Publishers' Trade List Annual. New York: F. Leypoldt. 1880. $1.50.

The Scientific Basis of Spiritualism. By Epes Sargent. Boston: Colby & Rich. 1881. Pp. 372. $1.50.

Medical Heresies. By Gonzalvo C. Smythe, M. D. Philadelphia: Presley Blakiston. 1880. Pp. 228. $1.25.

A New School Physiology. By Richard J. Dunglison, M. D. Philadelphia: Porter & Coates. 1880. Pp. 314. $1.50.

A Practical Treatise on Nervous Exhaustion. Second and revised edition. By George M. Beard, M. D. New York: William Wood & Co. 1880. $1.75.

Diphtheria. By Rollin R. Gregg, M. D. Buffalo: Printed by Matthews Brothers & Bryant. 1880. Pp. 133. For sale by Author. $1.50.

Handbook of Chemical Physiology and Pathology. By Victor C. Vaughan, M. D., Ph. D. Third edition, revised and enlarged. Ann Arbor. 1880. Pp. 351. Illustrated. $3.

Transcendental Physics. By Johann Carl Friedrich Zöllner. Translated by Charles Carleton Massey. Boston: Colby & Rich. 1881. $1.50.

British Thought and Thinkers. By George S. Morris, A. M. Chicago: S. C. Griggs & Co. 1880. Pp. 388. $1.75.

The Beautiful and the Sublime. By John Steinfort Kedney. New York: G. P. Putnam's Sons. 1880. Pp. 214. $1.25.

Is Consumption Contagious? By Herbert C. Clapp, M. D. Boston: Otis Clapp & Son. 1881. Pp. 178.

Report of the Commissioner of Education for the Year 1878. Washington: Government Printing-Office. 1880. Pp. 730.

The Care and Culture of Children. By Thomas S. Sozinskey, M. D., Ph. D. Philadelphia: H. C. Watts & Co. 1880. Pp. 484. $2 50.

Practical Plane Geometry and Projection. By Henry Angel. Vol. I. Text. Pp. 352. Vol. II. Plates. $3.50.

POPULAR MISCELLANY.

The Maxim Electric Light.—Some new electric-light apparatus has been in use in this city during the past month, which carries the solution of the problem of reducing this light to a form in which it will be available for the purpose of general lighting, further than any previous devices. It consists of a new incandescent lamp, in which the main feature is the means of compensating for the waste of the carbon strip, and an appliance by which the strength of the current is automatically varied in accordance with a varying number of lamps in circuit. The lamp is in appearance much like that of Mr. Edison's, the carbon strip being, however, bent into the form of a letter M, or of a Maltese cross, instead of a simple

bow. The carbon, which is made from paper or wood, is not placed in a vacuum, but in a rarefied atmosphere of gasoline, the idea involved being that, as the strip wears away under the action of the current, it will be continually renewed by the free carbon of the dissociated hydrocarbon vapor. This deposited carbon forms a hard, compact layer which seems to greatly increase the durability of the strip, and also the amount of light which it will yield under a given current. None, it is stated, have broken, even when forced much beyond the incandescence they are intended to bear, and, owing to the compensating action of the gasoline, it is anticipated that the lamps will be permanent. The platinum wires supporting the carbon strip are not fused into the glass of the bulb, as has been the case in previous incandescent lamps, but are surrounded by a slightly elastic cement, which it is averred preserves a good joint. The light given by the lamp is but slightly yellow, is quite pleasing to the eye, and is fairly steady. It has, however, a perceptible vibration, different from the irregular flicker of gas, but more painful, and which it seems impossible to eliminate, as it is due to the necessary variations of the engine-speed. As to cost, the inventor, Mr. H. S. Maxim, claims that he is able to produce ten lights of twenty candles each per horse-power. Professor Henry Morton, of the Stevens Institute, in a paper read before the American Academy of Science, at its recent meeting, stated that, experimenting with one of these lamps, he found that, when it was giving a light of forty candles, the expenditure for power was at the rate of 240 candles per horse-power. A twelve-candle light was at the rate of 136 candles, and, at 49 candles, was at the rate of 426 candles for the same power; while, when the lamp was forced to 98 candles, the expenditure was at the rate of 607 candles per horse-power. He also bore testimony to the value of the gasoline vapor in building up the carbon strip. It is doubtful, however, if the gasoline will prove in practice as free from disadvantage as expected. It will probably deposit in the form of a film on the glass, that may in time so obscure the light that a new lamp will be necessary. Such a deposit seems to have already taken place in some of the lamps at present on exhibition. The regulating device is quite simple in construction and certain in action. Its general mode of operation is as follows: The field magnets of the machine supplying the currents to the lamps are excited by another machine. The current furnished by this latter is varied in accordance with the number of lamps in circuit, by shifting its commutator brushes to and from the position in which they take off a maximum and minimum current. This shifting of the brushes is done by means of simple mechanism, actuated by an electro-magnet placed in the lamp-circuit, and therefore subject to the same conditions as the lights. Numerous trials have shown that this regulator is entirely reliable, and the adjustment of the current is so delicate that no observable difference has been detected in the light of a lamp whether one or sixty were in circuit.

The German Anthropological Society.—The eleventh meeting of the German Anthropological Society was held at Berlin, August 5th to 12th. The greater proportion of the papers read during the sessions related to relics discovered in Germany and the neighboring countries, most of which were newly found, or newly reported upon. Among the subjects of these papers were prehistoric earthworks and fortifications in Schleswig-Holstein; a Frankish burial-ground near Worms, in which burials in rows and in several courses of bodies were notable features, and where dogs and horses were found buried with the men, together with vessels of clay and glass of extraordinary size and beauty, and a unique bronze cup adorned with Christian emblems; the Frankish castle of Schlosseck in the Isenach Valley near Dürkheim, hitherto wholly unknown; a report by Professor Virchow upon the results of statistical researches into the color of the skin, hair, and eyes, illustrated by maps and tables; prehistoric charts of Germany by Professor O. Fraas; the German Runes, by Dr. Henning, of the University of Berlin. Dr. A. Bastian, who had returned from a journey of more than two years, undertaken for the study of facts relating to anthropology, spoke of the immensity of the task of perfecting the science, which he realized more completely than

ever. The present generation has to lay the foundation of the study and leave the task of building it up to posterity. We enjoy many advantages from intercourse with primitive people which those who will come after us may not possess; and we have much to do in gathering and preserving facts which are passing away with every year, day, hour even, lest through carelessness or neglect they shall disappear utterly. Every gap thus permitted will be painfully regretted in the future, when a detailed review shall be undertaken of the diversity of variations in which the human race has exhibited itself on the earth. The speaker insisted upon the necessity of ethnologists traveling among these primitive peoples, and spoke particularly of his observations in Polynesian mythology. The Polynesian circle of thought, he said, is, after the Buddhist, the most extensive on the earth. A surprising homogeneity prevails throughout the length and breadth of the Pacific Ocean, and still more widely if we consider Oceania in its full sense, with the inclusion of Polynesia and Melanesia. It may be said that this unity prevails over about one hundred and forty degrees of longitude and seventy degrees of latitude, or over one fourth of the globe. We can not ignore so interesting a phenomenon. A direct relation exists between the mythologies of all peoples and their religious notions, and the same is the case in Polynesia. Accounts of the mythologies of the primitive tribes generally afford senseless caricatures so long as we are not acquainted with the religious notions around which they play. The knowledge of these beliefs is not easily gained, for the priests hide their doctrines under symbols which only the initiated can understand. It requires a long residence in the country and a winning of the confidence of the priests to such a degree as to induce them to communicate the traditions that have been handed down to them in secrecy. In all the Polynesian literature that we possess there is nothing that goes to the heart of their religion beyond a few disconnected fragments which have been taken down by a half-dozen writers; and the cry is already going up that it is too late; that the holders of the uncontaminated traditions are passing away and carrying with them to the grave the knowledge they might impart. Professor Bastian stated that he had been able by a combination of favorable circumstances to gather a few of these documents, out of which he hoped to be able to effect a partial reconstruction of the Polynesian religious system.

Studies of Young Apes.—H. Schneider gives, in "Kosmos," an account of his observations of the habits and the development of the faculties of a young Javanese ape, which he had bought for purposes of study. The animal, when taken home, won at once the affection of Herr Schneider's wife, to whom he had anticipated it would be unwelcome. When awakened from its sleep in the woman's lap, it acted almost precisely as children do in similar circumstances—stretched its limbs, yawned with a very perceptible sound while its eyes were closed, rubbed its eyes, and scratched itself; then suddenly bounded up and went into its cage. It was not long before Chega—so it was named—began to show her dexterity. While playing in the room one day, she sprang upon the table, and before her master could prevent it, took up a half-filled cup of coffee from before him, ran to the sofa, and, standing upon its back, quietly drank the coffee, having finished which, she jumped down without having spilled a drop of the liquid. Her behavior was generally that of a spoiled child. When pleasantly spoken to, she was agreeable and playful; but if anything was denied her, or taken away from her, she would cry out, strike with her hands and feet, and go straight to the object and get it if she could. She would sit on her master's arm as he was playing at cards, and turn over the cards; or she would search in his pockets, looking most often for his watch, which she was very fond of getting. When she saw an effort made to catch her, she would mind no call, but would hide in the farthest corner. If capture was imminent, she would make a rueful face, with clinched teeth and parted lips, and utter a smacking sound. The danger over, a friendly word would restore her amiability at once. She would clasp her master's neck, put on a comical expression, and throw kisses at him. When spoken of by her master to a third person, even if she

seemed to be in a deep sleep, she would look up with signs of pleasure and utter a whimper of acknowledgment. When she had to be whipped, she would give up at once when caught, though never to any one but her master; but if his wife was in the room, she would run to her for protection, sounding a note of triumph while the master was looking out that she did not bite him in getting away from him. She was always betrayed by her guilty consciousness when she had done anything wrong, even if no one had observed her; and if detected, would act as a child acts under the shame of guilt. She was not greedy in eating except when denied something; then she would seize it with both hands, and stuff her cheeks so full that it would take a considerable time to eat what she had put away. At her regular meals she ate slowly. If a cup of milk was placed in the cage so that the shadow of one of the bars of the cage was thrown over it, she would look at the shadow, grasp after it, and then look astonished to find that she had not got hold of it, and would not drink until she had examined the cup from every side. In eating, she rejected the thinnest shells, the strings of beans, and the skins of nuts. She was induced to take medicine by pretending that she must not have it. If her master wished to give her rhubarb, he would play with a piece of the drug while Chega looked on wistfully; then seem to snatch it away so that she should not get it, and let it drop, as if accidentally, out of his hand, when in an instant it would be seized or swallowed; or, if not already swallowed, would be if an effort was pretended to take it away. Chega was fond of her master's Spitz dog, and had many frolics with him. Once they were chasing each other between the sofa and the table, when the ape got into a position between the two where the dog could not follow her, but staid upon the table looking at her. In an instant she took hold of the table-cloth with both hands and brought it down, with the dog in it, upon the floor. While the astonished dog was trying to release himself from the folds of the cloth, Chega ran to the window-sill and clapped her hands in evident pleasure over the success of her trick. Chega slept with her master for three years, lying with one of her arms around his neck, while her other hand was in his. To prevent her getting away in the night, her master fixed a cord to her neck, so that she should wake him when she moved. She soon learned the secret of the cord and how to unhitch it, and would unhook the neck-band, take out a pin, lay the whole carefully aside, and spring up to go, when she would be stopped. Chega seemed to have dreams, as men and children often do, of falling from a height, and would draw up her limbs with the convulsive motion that all are aware of. Herr Schneider believes that his pet exhibited in a wonderful degree the faculties of reflection and comparison. Dr. Julius Falkenstein has given, in his account of the German Loango Expedition, a narrative of the early life-history of the gorilla Mpungu, which was obtained and brought home by the expedition, and was afterward exhibited in the Berlin Aquarium. While in Africa, the young animal was kept as free as possible from other than natural influences, so that its habits might be studied as accurately as was practicable. Mpungu gave a contradiction to the reports of the fierce and untamable character of the gorilla, for he soon became accustomed to the persons around him, showing a real dependence upon them and confidence in them, and was allowed to run about with no more care than a child. He gave no evidence of evil or malicious propensities, but had a will of his own, and distinct tones of voice in which to express his feelings. The representations of Du Chaillu concerning the gorilla's beating his breast were confirmed by this animal. The action indicated an excess of physical good feeling, and was never observed while the animal was in Europe, because he never enjoyed good health there. Pleasure in bodily vigor was also frequently exhibited in reelings and tumblings like those of a drunken man. When anything was given to the young gorilla in a cup or glass, he would take it up carefully with both hands, bring it to his mouth, and, having drunk, set it down as carefully; and he was never known to break a dish. Yet he was never taught how to use dishes. He took in eating only as much food at a time as he could hold between his thumb and two fingers, and would observe the removal of the mass of food with indifference;

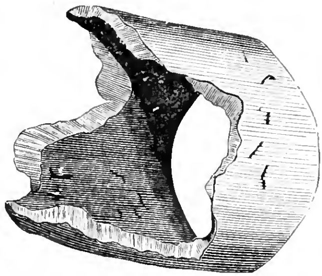
but, if not helped, he would glance at the dishes around him with an impatient murmur, and try to attract the attention of the waiters with a cough or by touching them. If he drank out of a vessel which he could not lift, he would bend down to it without touching it with his hands or disturbing it. He was particularly neat, seemed annoyed if anything fell upon him or stuck to him, and would pick it off carefully, or would hold up his hands and let some person pick it off; he was free from odors, and was very fond of playing and splashing around in the water. His most prominent individual peculiarities were good humor and cunning. If punished, he never resented it, but would lock his feet together and look up with an expression that disarmed all ill feeling. When he wanted anything, he could make his wish known as expressively and persuasively as any child. If it was not granted he would not give it up, but would wait for his chance with every evidence that he had a plan in his head. Thus, if he wanted to go out, and was refused, he would seem to submit and lie down in assumed indifference not far from the door, raising his head occasionally to see if his opportunity had come, and would gradually draw nearer to the door, keeping careful watch all the time, and at last would go out so quickly that no one could stop him. Whenever he intended to steal sugar or fruit from the cupboard, he would keep looking in the opposite direction till he was not observed, and then would go directly to the cupboard, open the door, and, having shut it behind him, would take out carefully whatever he wanted and eat it as quickly as possible. If detected, he would run away, and his whole demeanor would indicate that he knew he was doing what was forbidden. He took great pleasure in drumming on hollow things, and seldom let an opportunity pass of doing so. Unaccustomed noises were annoying to him. Thunder, the pattering of the rain on the awnings of the ship, the sound of the trumpet and the pipe, gave him so much pain that it was an act of mercy to get him out of hearing of them as quickly as possible. Mpungu declined after he was taken to Europe, and died in a little more than two years after he was caught.

The Stone-Grains in Fruit.—Henry Polonié considers, in "Kosmos," the nature of the gritty particles in pears and other fruits of the apple family. Each of these bodies consists of several cells which may be called stone-cells, and which have walls of considerable strength, traversed by canals. The stone-cells are widely distributed through the vegetable kingdom, and form an essential part of the framework of many plants. In these cases they perform mechanical functions, as they do also in grapes or stone fruits, where they form strong walls protecting the seed. The mechanical office does not, however, appear in the pear, for the stone-grains are scattered irregularly in the pulp of the fruit. M. Polonié suggests that they may be the rudimentary remains of a stone casing to the seeds of some ancestor of our present cultivated and wild pears. It is in favor of this theory that the stony pear-grains are not evenly distributed through the whole fruit, but are thickest in a zone surrounding the seeds, and where we should expect to find the shell of the stone if the pear was a proper stone-fruit. By bringing together the different varieties of cultivated and wild or wood pears, we might arrange a series of fruits in regular gradation, from a luscious pear with hardly any stony grains down to a tough wood-pear, in which these grains would be so close as to touch each other all around. If the latter pear is dried, the stony surrounding becomes so hard that it is difficult to cut through it. M. Polonié has found this to be the case with certain wild pears which he has observed. This theory is also supported by the analogy of certain genera related to the pear whose fruits inclose stones, as the medlar, which has fine stony seeds; certain species of thorn, in which the seeds are merged into one kernel surrounded by a stony envelope, and some exotic genera, as the East Indian stranæsia, in which all the seeds are surrounded by a common stony envelope. The quince has also gritty particles, which are distributed similarly with those of the pear; and a quince from the shores of the Caspian Sea, which is preserved in the herbarium at Berlin, has its stone-grains thickly grouped in a hard mass surrounding the seeds, like the wood-pears mentioned by M. Polonié.

Craniology of the Africans.—M. de Quatrefages recently explained to the French Academy of Sciences the results of the researches of M. Hamy on the craniology of the African races. Far from all the negroes of Africa being dolichocephalous (or long-skulled), there exist on the continent diverse populations, forming two distinct groups, which pass in succession from the sub-brachycephalic (moderately short-skulled) to the mesocephalic (medium-skulled) and to the sub-dolichocephalic, and finally to the true dolichocephalic type. In other words, the relation of the transverse diameter to the antero-posterior diameter of the skull goes on progressively diminishing. M. Hamy has also studied the race of the dwarf negroes, and finds that their skulls are quite as much arched as those of the other human races. Their stature nearly approaches that of the Mincopies of the Andaman Islands, but it is superior to that of the Bushmen, whose height often falls to one metre (three feet three inches), sometimes to 1·14 metre (three feet eight and a half inches). This race probably approaches the true brachycephalic type. M. Hamy joins in a single race the Noubas, the Fourahs, the Gallas, the Nyam-Nyams, etc., and attaches to the same group, which is generally Eastern, the Haoussas who live west of Lake Tchad, although a population craniologically distinct is situated between them.

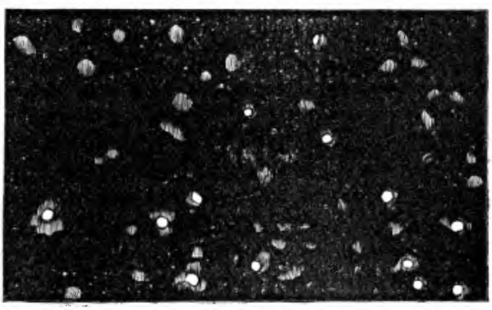
Rats and Lead Pipes.—One of the best foreign authorities on sanitary engineering, Dr. William Eassie, has an interesting letter in a late number of the "Sanitary Record" on the destruction of lead pipes and flashings by rats, mice, and even timber-worms. He relates several cases, either seen by himself or brought to his attention by others, in which lead waste-pipes were perforated with veritable rat-holes, thus admitting not only sewer-gas but the rats themselves into the house. Fig. 1 is reproduced from Dr. Eassie's letter, and represents a piece of two-inch lead pipe a quarter of an inch thick, which was once a part of the waste-pipe of a sink in a house in London. This pipe terminated in an old brick drain infested with rats. "The rats obtained ingress to the house by way of this pipe, that is certain; and on taking up the floor some hundreds of these animals were destroyed and many missing articles

Fig. 1.



recovered. The marks of their teeth are very plainly exhibited, as may be seen by a glance at the woodcut, which does not exaggerate them in any way." Fig. 2 represents a piece of lead flashing obtained by Dr. Eassie from the roof of an infirmary in the north of England. The woodwork below had been first destroyed by wood-borers, and the light, shaded marks in the cut show

Fig. 2.



where the acid of the destroyed wood had partially eaten away the lead. The white holes are actual perforations to the open air. Other instances of a like character are given, and all go to show that lead, where so exposed, is not a safe plumbing material.

A Musical Valley.—In an essay on "The Singing Valley of Thronecken," Herr H. Reulaux has described an enduring sound like the ringing of bells, which he heard while engaged in a deer-hunt in an elevated wooded valley in the Rhine Province. He had before heard sounds in the valley, re-

sembling those which might come from a church in some town hidden in its recesses; but there was no such town in the neighborhood. On the occasion which he especially describes, he took his place as one of the hunters in a wood of large beech-trees lying against the slope of the mountain, and was treated all the time he stood there to a succession of peals as of bells, coming one upon another, swelling up and dying away, and sounding together in many varieties of modulation, and in all the different stages of progress. At times the impression of the music was so strong as to hold him almost breathless; then a new wave would sweep up, beginning like the soft breathing of an organ-pipe, rising to the swell of a harp, and closing with the overtone of the octave, as if it were drawn out by some master of the violin. When the hunter returned to the same place toward evening, he heard the same sounds. One other of the hunters remarked them, but the rest were absorbed in their sport. A forester blew the tone of C on his horn, and it was repeated in the bell-peals. The tones evidently originated in the mouth of the valley and died away in its upper part. They were produced by the passage of the wind through the valley, and modified by its configuration, the character of the rocks, and, probably, by the wood.

Animals or Plants?—In the course of a lecture on "Plants that prey upon Animals, and Animals that fertilize Plants," delivered at Leeds recently, by the Rev. W. H. Dallinger, the lecturer explained that there were animals—definitely proved to be such, and with which every zoölogist was familiar—that were so lowly in their being that they possessed no definite form. They revealed to the most refined scrutiny no organization. They moved, but without muscle; they crept, but without limbs; they felt, but without discoverable nerves; they devoured without mouths; they digested without stomachs; and they had all the properties of life, but were without trace of organized structure. It was their habit to associate with even these lowly creatures, because they were animals, a measure, at least, of consciousness and volition. But, on the other hand, there were plants of the highest and most compact structure in which delicacy of organization, refinement of mechanical contrivances, and adaptation of means to ends, were combined; and yet, because they were vegetables, they were accustomed to assume that they were without consciousness, and devoid of will. But what were the facts? Zoölogy at the present day was in the highest sense a science. Its facts had a precision and value unrivaled, and from these they were bound to say that the old landmarks were utterly incompetent. The animal and vegetable kingdoms could not be separated, and the two marched on in one organic whole. To the popular mind he had no doubt this would appear arrogant. To common observation the distinction between the plant and the animal was believed to be sufficiently clear. Between an ox and an oak-tree there was an unmistakable difference. A cabbage and a swallow were not very easily confounded. This was quite true; but if the entire of what was known as the animal world were laid against the whole of what was known as the vegetable kingdom, it would be seen that there were no features belonging to the one which were not in some sense shared by the other. There were vegetables controlled by movements which in animals would be called instincts. They could intoxicate a plant as they could intoxicate a man or beast; they could paralyze it with pain or chloroform, and could kill it with an electric spark. There were some plants which depended for existence on the animals they entrapped, and to this end they were endowed with a susceptibility more delicate than that of the human body, while they could distinguish between food which would nourish them and substances which would not. It was not too much to say that the extinction of insects would lead to the extermination of the most beautiful plants existing on the globe; while the extinction of these beautiful plants would, in like manner, be the ruin of the majority of insects.—*English Mechanic.*

Efficacy of Sanitary Improvement.—Two reports have recently been published in Great Britain which illustrate what has been accomplished in lessening the prevalence of disease and prolonging human life by measures of sanitary improvement. The improvement trustees of Glasgow have given out a statement showing that the

average death-rate per one thousand persons has been reduced nearly eleven per cent. in twelve years, under the operation of the sanitary measures instituted by them, which included the demolition of unwholesome dwellings, and the provision of ample hospital space for small-pox and fever cases, and for the control and limitation of epidemic disease. They also cite from the report of the Registrar-General figures showing that a similar improvement in sanitary condition has been wrought in other towns: in Edinburgh of fourteen, in Dundee of twelve, in Aberdeen (where the death-rate was already very low) of three and one-half per cent. The figures given of a number of English towns show a less striking rate of improvement. Dividing the twelve years into two groups of six years each, it is found that, in twelve leading towns, 61,000 fewer deaths occurred in the second six years (1873–'78) than would have occurred under the higher death-rates of 1867–'72. The sanitary officer of Manchester has reported to the bishop of the diocese that, under the operation of the measures which have been adopted in that city, "typhus and typhoid fever, though not absolutely extinguished, are of comparatively rare occurrence, and nearly all other infectious diseases have been largely reduced in amount, while the general health has been improved."

An Antarctic Expedition.—The Italian Geographical Society has projected an Antarctic exploring expedition, to be under the command of Lieutenant Beve, an Italian officer who was with Nordenskjold during his last expedition. Very little is definitely known concerning the Antarctic regions, and they offer numerous problems to be solved. They have been touched upon, but can hardly be said to have been explored, by several navigators since Captain Cook crossed the Antarctic Circle in 1774–'75, including Lieutenant Wilkes with the American Expedition, but the results of the observations made upon them do not agree. Even the Challenger Expedition, in 1873, added but little to our knowledge of them. It is still not fully settled whether the region be only an immense mass of water or whether it contains another continent. Lieutenant Wilkes believed that he had established the existence of a continent, but Sir James Ross a year later sailed over two of the positions assigned by him to the continent, while he found the extensive Victoria Land with mountains 14,000 feet high and an active volcano. The great ice-sheet, which certainly covers the land, needs to be studied and compared with the ice-sheet of Greenland. Lieutenant Beve and his companions hope to winter in the Antarctic region, and to be more successful in studying its character than their predecessors have been.

NOTES.

A Holtz frictional electric machine, said to be the largest ever made in this country, has recently been constructed by a well-known firm manufacturing physical and chemical apparatus in this city. The revolving glass disk is forty and the condensing stationary disk forty-six inches in diameter. It is provided with the continuous charging apparatus of Van Brunt, which is a very considerable improvement over the ordinary means of charging by rubbing a disk of vulcanite with a skin by hand. The machine gives a discharge over twenty inches long, and, on account of the facility of charging, can be satisfactorily worked in almost any weather.

At a late meeting of the California Academy of Sciences, Mr. W. N. Lockington read a paper on fishes, in which he states that of three hundred and eight species, mostly marine, occurring on the Pacific coast, all but thirty-seven are found in California. Of the five hundred and forty fresh-water species known in the United States, but thirty-seven are found in that State.

That ants can make themselves heard as well as felt, is asserted by Mr. S. E. Peal, who writes to "Nature" that he has observed in several varieties of this insect the power of producing distinctly audible sounds. Two kinds of ants, one brown the other black in color, could be heard a distance of twenty or thirty feet, the noise being produced by scraping the horny apex of the abdomen three times in rapid succession against the dry leaves of the nest.

Dr. Ephraim Cutter describes in the October number of the "American Monthly Microscopical Journal" an interesting study he has lately made of the central surface-waters of several ponds and lakes in Massachusetts. He found, contrary to the general opinion, that the waters in the middle of ponds or lakes contain large numbers of mi-

croscopic forms of both vegetable and animal life.

The experiment of irrigating the lands at Genevilliers with water from the sewers of Paris appears to be working successfully. In answer to protests which have been made against applying a similar irrigation to the forests of St. Germain, the engineers say that the apprehensions that have been expressed on the subject are exaggerated. Many buildings have been put up at Genevilliers since the sewer-waters were taken there, but the inhabitants have never been sick. Moreover, since the prevailing winds are from the west, places lying east of the irrigated district should be the ones most troubled with the infection if there were any; but no complaint has come from Clichy, which is thus situated, while the barren tracts on which it looked have been converted into a fertile plain.

The French journals tell of some perfectly fresh meat that became phosphorescent. Some cutlets of raw pork shone so brightly in the kitchen that it was possible by the aid of the light to tell the time by the watch. The butcher from whose shop they came said that all the meat of which they were a part of the stock became phosphorescent within a short time after having been put into his cellar. The phosphorescent meat did not otherwise differ in aspect or odor from common meat; it had not been exposed to a temperature of more than 50°, and entire freshness seemed to be a condition of phosphorescence, so that when the meat began to smell it ceased to be bright. The phosphorescence generally disappeared on the sixth or seventh day.

M. L. Cruls has communicated to the French Academy of Sciences notes of observations which he has made at the Imperial Observatory, Rio Janeiro, on stars unfavorably situated for observation from the Northern Hemisphere. Some of these stars appear to possess a slow but well-defined orbital motion, amounting in some instances to about six degrees retrograde in forty-three years. They have been observed heretofore only by Sir John Herschel at the Cape of Good Hope, and by Captain Jacob at Poonah, India, and it is from a comparison with their observations that he has deduced the fact of motion.

The Royal Society has this year awarded the Copley Medal to Professor J. J. Sylvester, at present occupying the chair of Mathematics in Johns Hopkins University.

M. de Lesseps has a plan for the civilization of Africa by telegraph. Stations for entertainment and for scientific purposes are to be established at points between the coasts and the interior. Thus a party has already arrived in the Oussagura to establish a station to be connected with Zanzibar, and another party has been commissioned to establish a station on the Ogove River to be connected with the French colony at the Gaboon. The stations are to be connected by telegraphic wires, the planting of which will be preliminary to the building of railways, so that these wires, says M. de Lesseps, will become for Africa, as they were across our Western Plains and are for Australia and for the Russians in Central Asia, real conductors of civilization.

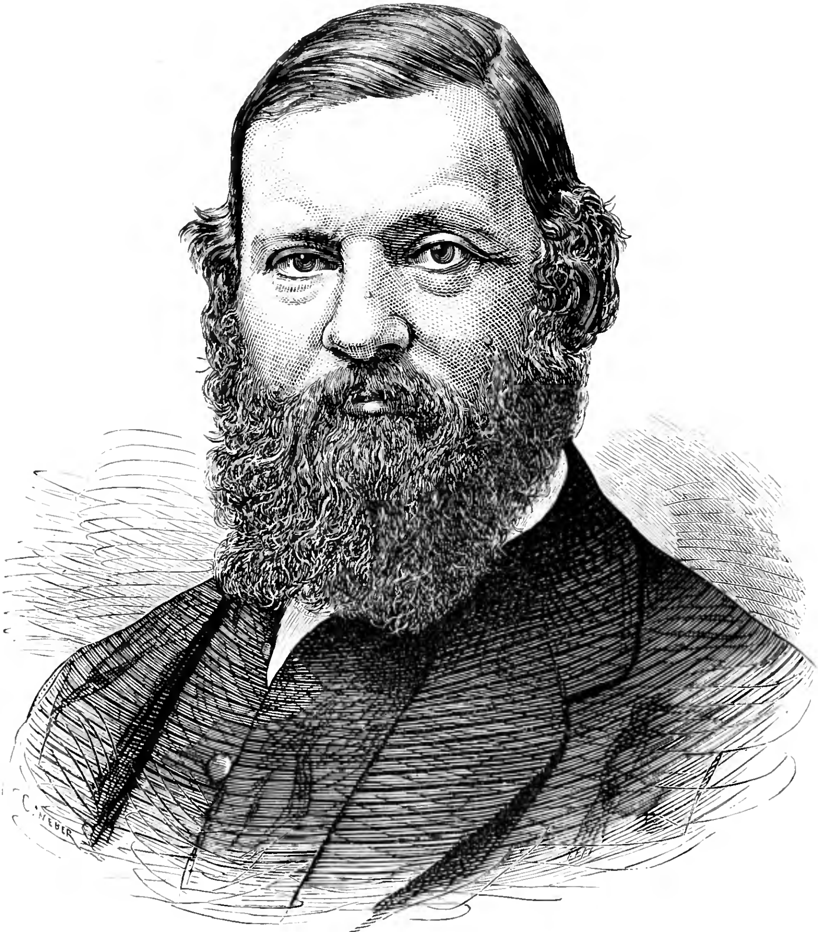
Professor Henry Draper writes in the November number of the "American Journal of Science" that, "during the night of September 30, 1880, I succeeded in photographing the bright part of the nebula in Orion in the vicinity of the trapezium. The photographs show the mottled appearance of this region distinctly. They were taken by the aid of a triple objective of eleven inches aperture, made by Alvan Clark & Sons, and corrected especially for the photographic rays. The equatorial stand and driving clock I constructed myself. The exposure was for fifty minutes. I intend at an early date to publish a detailed description of the negatives."

M. Abel Pifre has succeeded, by changing the form of the reflectors and the heaters, in considerably increasing the efficiency of the solar engines invented by M. Mouchot. While M. Mouchot has not been able to utilize more than fifty per cent. of the heat of the sun, M. Pifre with his improved apparatus makes eighty per cent. available for use. With a receiver of 9·25 square metres and a clear sky he boils fifty litres of water in less than forty minutes, and obtains an additional pressure of one atmosphere every seven or eight minutes.

It is proposed to make use of the hydraulic constructions and machinery at Airolo and Goeschenen for the maintenance of electric lights in the St. Gothard Tunnel.

A rock-drill run by electricity has been devised by Messrs. Siemens and Halske of England. It consists of a rod of steel-headed soft iron which moves through three coils of insulated wire; the middle coil is traversed by a constant current which magnetizes the rod, and the other coils are traversed by alternating currents which attract and repel the rod with rapid movements.

"Nature" chronicles the death of Dr. Hofrath von Wagner, Professor of Technological Chemistry in the University of Würzburg. He was born at Leipsic in 1823, first taught in Nüremberg, and was the author of a standard work on chemical technology, translated into English by Professor Crookes in 1872.



LOUIS FRANÇOIS DE POURTALES.

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THE DEVELOPMENT OF POLITICAL INSTITUTIONS.

By HERBERT SPENCER.

IV.—POLITICAL DIFFERENTIATION.

THE general law, that like units exposed to like forces tend to integrate, was in the last chapter exemplified by the formation of social groups. The clustering of men who are similar in kind, when similarly subject to hostile actions from without, and similarly reacting against them, we saw to be the first step in social evolution. Here the correlative general law, that in proportion as the like units of an aggregate are exposed to unlike forces they tend to form differentiated parts of the aggregate, has to be observed in its application to such groups, as the second step in social evolution.

The primary political differentiation originates from the primary family differentiation. Men and women being, by the unlikenesses of their functions in life, exposed to unlike influences, begin from the first to assume unlike positions in the social group as they do in the family group: very early they respectively form the two political classes of rulers and ruled. And, how truly such dissimilarity of social positions as arises between them is caused by dissimilarity in their relations to surrounding actions, we shall see, on observing that the one is small or great according as the other is small or great. When treating of the *status* of women, it was pointed out that to a considerable degree among the Chippewas, and to a still greater degree among the Clatsops and Chinooks, "who live upon fish and roots, which the women are equally expert with the men in procuring, the former have a rank and influence very rarely found among Indians." We saw also that in Cueba, where the women join the men in war, "fighting by their side," their position is much higher than usual among rude peo-

ples; and, similarly, that in Dahomey, where the women are as much warriors as the men, they are so regarded that, in the political organization, "the woman is officially superior." On contrasting these exceptional cases with the ordinary cases, in which the men, solely occupied in war and the chase, have unlimited authority, while the women, occupied in gathering miscellaneous small food and carrying burdens, are abject slaves, it becomes manifest that diversity of relations to surrounding actions initiates diversity of social positions. And, as we before saw, this truth is further illustrated by those few uncivilized societies which are habitually peaceful, such as the Bodo and Dhimáls of the Indian hills, and the ancient Pueblos of North America—societies in which the occupations are not, or were not broadly divided into fighting and working, and severally assigned to the two sexes; and in which, along with a comparatively small difference in the activities of the sexes, there goes, or went, small difference of social *status*.

So is it when we pass from the greater or less political differentiation which accompanies difference of sex to that which is independent of sex—to that which arises among men. Where the life is permanently peaceful, definite class-divisions do not exist. One of the Indian Hill-tribes, to which I have frequently referred as exhibiting the honesty, truthfulness, and amiability accompanying a purely industrial life, may be instanced. Hodgson says, "All Bodo and all Dhimáls are equal—absolutely so in right or law—wonderfully so in fact." The like is said of another peaceful and amiable Hill-tribe: "The Lepchas have no caste distinctions." And among a different race, the Papuans, may be named the peaceful Arafuras as displaying a "brotherly love with one another," and as having no divisions of rank.

As, at first, the domestic relation between the sexes passes into a political relation, such that men and women become, in militant groups, the ruling class and the subject class, so does the relation between master and slave, originally a domestic one, pass into a political one as fast as, by habitual war, the making of slaves becomes general. It is with the formation of a slave-class that there begins that political differentiation between the regulating structures and the sustaining structures which continues throughout all higher forms of social evolution.

Kane remarks that "slavery in its most cruel form exists among the Indians of the whole coast from California to Behring's Straits, the stronger tribes making slaves of all the others they can conquer. In the interior, where there is but little warfare, slavery does not exist." And this statement does but exhibit, in a distinct form, the truth everywhere obvious. Evidence suggests that the practice of enslavement diverged by small steps from the practice of cannibalism. Concerning the Nootkas, we read that "slaves are occasionally sacri-

ficed and feasted upon"; and if we contrast this usage with the usage common elsewhere, of slaying and devouring captives as soon as they are taken, we may infer that the keeping of captives too numerous to be immediately eaten, with the view of eating them subsequently, leading, as it would, to the employment of them in the mean time, led to the discovery that their services might be of more value than their flesh, and so initiated the habit of preserving them as slaves. Be this as it may, however, we find that very generally, among tribes to which habitual militancy has given some slight degree of the appropriate structure, the enslavement of prisoners becomes an established habit. That women and children taken in war, and such men as have not been slain, naturally fall into unqualified servitude is manifest. They belong absolutely to their captors, who might have killed them, and who retain the right afterward to kill them, if they please. They become property, of which any use whatever may be made.

The acquirement of slaves, which is at first an incident of war, becomes presently an object of war. Of the Nootkas we read that "some of the smaller tribes at the north of the island are practically regarded as slave-breeding tribes, and are attacked periodically by stronger tribes"; and the like happens among the Chinooks. It was thus in ancient Vera Paz, where periodically they made "an inroad into the enemy's territory, . . . and captured as many as they wanted"; and it was so in Honduras, where, in declaring war, they gave their enemies notice that "they wanted slaves." Similarly with various existing peoples. St. John says that "many of the Dyaks are more desirous to obtain slaves than heads, and in attacking a village kill only those who resist or attempt to escape." And that in Africa slave-making wars are common needs no proof.

The class-division, thus initiated by war, afterward maintains and strengthens itself in sundry ways. Very soon there begins the custom of purchase. The Chinooks, besides slaves who have been captured, have slaves who were bought as children from their neighbors; and, as we saw when dealing with the domestic relations, the selling of their children into slavery is by no means uncommon with savages. Then the slave-class, thus early enlarged by purchase, comes afterward to be otherwise enlarged. There is voluntary acceptance of slavery for the sake of protection; there is enslavement for debt; there is enslavement for crime.

Leaving details, we need here note only that this political differentiation which war begins is effected, not by the bodily incorporation of other societies, or whole classes belonging to other societies, but by the incorporation of single members of other societies, and by like individual accretions. Composed of units who are detached from their original social relations and from one another, and absolutely attached to their owners, the slave-class is, at first, but indistinctly separated as a social stratum. It acquires separateness only as fast as there arise

some restrictions on the powers of the owners. Ceasing to stand in the position of domestic cattle, slaves begin to form a division of the body-politic, when their personal claims begin to be distinguished as limiting the claims of their masters.

It is commonly supposed that serfdom arises by mitigation of slavery; but examination of the facts shows that it arises in a different way. While, during the early struggles for existence between them, primitive tribes, growing at one another's expense by incorporating separately the individuals they capture, thus form a class of absolute slaves, the formation of a servile class, considerably higher, and having a distinct social *status*, accompanies that later and larger process of growth under which one society incorporates other societies bodily. Serfdom originates along with conquest and annexation.

For whereas the one implies that the captured people are detached from their homes, the other implies that the subjugated people continue in their homes. Thomson remarks that, "among the New-Zealanders, whole tribes sometimes became nominally slaves when conquered, although permitted to live at their usual places of residence, on condition of paying tribute, in food, etc."—a statement which shows the origin of kindred arrangements in allied societies. Of the Sandwich Islands government when first known, described as consisting of a king with turbulent chiefs, who had been subjected in comparatively recent times, Ellis writes, "The common people are generally considered as attached to the soil, and are transferred with the land from one chief to another." Before the late changes in Feejee, there were enslaved districts; and of their inhabitants we read that they had to supply the chiefs' houses "with daily food, and build and keep them in repair." Though conquered peoples, thus placed, differ widely in the degrees of their subjection—being at the one extreme, as in Feejee, liable to be eaten when wanted, and at the other extreme called on only to give specified proportions of produce or labor—yet they remain alike as being undetached from their original places of residence. That serfdom in Europe originated in an analogous way there is good reason to believe. In Greece we have the case of Crete, where, under the conquering Dorians, there existed a vassal population, formed, it would seem, partly of the aborigines and partly of preceding conquerors, of which the first were serfs attached to lands of the state and of individuals, and the others had become tributary land-owners. In Sparta the like relations were established by like causes: there were the helots, who lived on, and cultivated, the lands of their Spartan masters, and the periœci, who had probably been, before the Dorian invasion, the superior class. So was it also in the Greek colonies afterward founded, such as Syracuse, where the aborigines became serfs. Similarly in later times and nearer regions. When Gaul was overrun by the Romans, and again when Romanized Gaul was overrun by the

Franks, there was little displacement of the actual cultivators of the soil, but these simply fell into lower positions: certainly lower political positions, and M. Guizot thinks lower industrial positions. Our own country, too, furnishes good illustrations. In ancient British times, writes Pearson, "it is probable that, in parts at least, there were servile villages, occupied by a kindred but conquered race, the first occupants of the soil." More trustworthy, but to the like effect, is the evidence which comes to us from old English days and Norman days. Professor Stubbs says: "The ceorl had his right in the common land of his township; his Latin name, villanus, had been a symbol of freedom, but his privileges were bound to the land, and when the Norman lord took the land he took the villein with it. Still the villein retained his customary rights, his house and land and rights of wood and hay; his lord's demesne depended for cultivation on his services, and he had in his lord's sense of self-interest the sort of protection that was shared by the horse and the ox." And of kindred import is the following passage from Innes: "I have said that, of the inhabitants of the Grange, the lowest in the scale was the *ceorl*, *bond*, *serf*, or villein, who was transferred like the land on which he labored, and who might be caught and brought back if he attempted to escape, like a stray ox or sheep. Their legal name of *nativus*, or *neyf*, which I have not found but in Britain, seems to point to their origin in the native race, the original possessors of the soil. . . . In the register of Dunfermline are numerous 'genealogies,' or stud-books, for enabling the lord to trace and reclaim his stock of serfs by descent. It is observable that most of them are of Celtic names."

Clearly, a subjugated territory, useless without cultivators, was left in the hands of the original cultivators because nothing was to be gained by putting others in their places, even could an adequate number of others be had. Hence, while it became the conqueror's interest to tie each original cultivator to the soil, it also became his interest to let him have such an amount of produce as to maintain him and enable him to rear offspring, and also to protect him against injuries which would incapacitate him for work.

To show how fundamental is the distinction between bondage of the primitive type and the bondage of serfdom, it needs but to add that, while the one can and does exist among savages and pastoral tribes, the other becomes possible only after the agricultural stage is reached; for only then can there occur the bodily annexation of one society by another, and only then can there be any tying to the soil.

Associated men, who live by hunting, and to whom the area occupied is of value only as a habitat for game, can not well have anything more than a common participation in the use of this occupied area: such ownership of it as they have must be joint ownership. Naturally, then, at the outset, all the adult males, who are at once hunters and

warriors, are the common possessors of the undivided land, encroachment on which by other tribes they resist. Though, in the earlier pastoral state, especially where the barrenness of the region involves wide dispersion, there is no definite proprietorship of the tract wandered over; yet, as is shown us in the strife between the herdsmen of Abraham and those of Lot respecting feeding-grounds, some claims to exclusive use tend to arise; and at a later half-pastoral stage, as among the ancient Germans, the wanderings of each division fall within prescribed limits. I refer to these facts by way of showing the identity established at the outset between the militant class and the land-owning class. For, whether the group is one which lives by hunting or one which lives by feeding cattle, any slaves its members possess are excluded from land-ownership—the freemen, who are all fighting men, become, as a matter of course, the proprietors of their territory. This connection, in variously modified forms, long continues through subsequent stages of social evolution, and could scarcely do otherwise. Land being, in early settled communities, the almost exclusive source of wealth, it happens inevitably that, during times in which the principle that might is right remains unqualified, personal power and possession of land go together. Hence the fact that, where, instead of being held by the whole society, land comes to be parceled out among component village communities, or among families, or among individuals, possession of it habitually goes along with the bearing of arms. In ancient Egypt "every soldier was a land-owner"—"had an allotment of land of about six acres." In Greece the invading Hellenes, wresting the soil from its original holders, joined military service with the land-ownership. In Rome, too, "every freeholder, from the seventeenth to the sixtieth year of his age, was under obligation of service, . . . so that even the emancipated slave had to serve, who, in an exceptional case, had come into possession of landed property." The like happened in the early Teutonic community. Joined with professional warriors, its army included "the mass of freemen, arranged in families, fighting for their homesteads and hearths": such freemen, or markmen, owning land partly in common and partly as individual proprietors. Similarly with the ancient English: "Their occupation of the land as *cognationes* resulted from their enrollment in the field, where each kindred was drawn up under an officer of its own lineage and appointment"; and so close was this dependence that "a thane forfeited his hereditary freehold by misconduct in battle."

Beyond the original connection between militancy and land-owning, which naturally arises from the joint interest which those who own the land and occupy it, either individually or collectively, have in resisting aggressors, there arises later a further connection. As, along with successful militancy, there progresses a social evolution which gives to a dominant ruler increased power, it becomes his cus-

tom to reward his leading soldiers by grants of land. Early Egyptian kings "bestowed on distinguished military officers" portions of the crown domains. When the barbarians were enrolled as Roman soldiers, "they were paid also by assignments of land according to a custom which prevailed in the imperial armies. The possession of these lands was given to them on condition of the son becoming a soldier like his father." And that kindred usages were general throughout the feudal period is a familiar truth : feudal tenancy being, indeed, thus constituted, and inability to bear arms being a reason for excluding women from succession. To exemplify the nature of the relation established, it will suffice to name the facts that "William the Conqueror . . . distributed this kingdom into about sixty thousand parcels, of nearly equal value, from each of which the service of a soldier was due," and that one of his laws requires all owners of land to "swear that they become vassals or tenants," and will "defend their lord's territories and title as well as his person" by "knight service on horseback."

That this original relation between land-owning and militancy long survived, we are shown by the armorial bearings of county families, as well as by their portraits of ancestors who are mostly represented in military costume.

Setting out with the class of warriors, or men bearing arms, who in primitive communities are owners of the land, collectively or individually, or partly one and partly the other, there arises the question, How does this class differentiate into nobles and freemen ?

The most general reply is, of course, that since the state of homogeneity is by necessity unstable, time inevitably brings about inequality of positions among those whose positions were at first equal. Before the semi-civilized state is reached the differentiation can not become decided, because there can be no large accumulations of wealth, and because the laws of descent do not favor maintenance of such accumulations as are possible. But in the pastoral and still more in the agricultural community, especially where descent through males has been established, several causes of differentiation come into play. There is first that of unlikeness of kinship to the head-man. Obviously, in course of generations, the younger descendants of the younger become more and more remotely related to the eldest descendant of the eldest, and social inferiority arises : as the obligation to execute blood-revenge for a murdered member of the family does not extend beyond a certain degree of relationship (in ancient France not beyond the seventh), so neither does the accompanying distinction. From the same cause comes inferiority in point of possessions. Inheritance by the eldest male from generation to generation brings about the result that those who are the most distantly connected in blood with the head of the group are also the poorest. And then there coöperates

with these factors a consequent factor—namely, the extra power which the greater wealth gives. For when there arise disputes within the tribe, the richer are those who, by their better appliances for defense and their greater ability to purchase aid, naturally have the advantage over the poorer. Proof that this is a potent cause is found in a fact named by Sir Henry Maine: "The founders of a part of our modern European aristocracy, the Danish, are known to have been originally peasants who fortified their houses during deadly village struggles, and then used their advantage." Such superiorities of power and position once initiated are increased in another way. Already in the last chapter we have seen that communities are to a certain extent increased by the addition of fugitives from other communities—sometimes criminals, sometimes those who are oppressed. While, in places where such fugitives belong to races of superior type, they often become rulers (as among many Indian Hill-tribes, whose rajahs are of Hindoo extraction), in places where they are of the same race, and can not do this, they attach themselves to those of chief power in their adopted tribe. Sometimes they yield up their freedom for the sake of protection: a man will make himself a slave by breaking a spear in the presence of his wished-for master, as among the East Africans, or by inflicting some small bodily injury upon him, as among the Fulahs. And in ancient Rome the semi-slave class distinguished as clients originated by this voluntary acceptance of servitude with safety. But, where his aid promises to be of value as a warrior, the fugitive offers himself in that capacity in exchange for maintenance and refuge. Other things equal, he joins himself to some one marked by superiority of power and property, and thus enables the man already dominant to become more dominant. Such armed dependents, having as aliens no claims to the lands of the group, and bound to its head only by fealty, answer in position to the *comites* as found in the early German communities, and as exemplified in old English times by the "Huscarlas" (house-carls), with whom nobles surrounded themselves. Evidently, too, followers of this kind, having certain interests in common with their protector, and no interests in common with the rest of the community, become, in his hands, the means of usurping communal rights and elevating himself while depressing the rest.

Step by step the contrast strengthens. Beyond such as have voluntarily made themselves slaves to a head-man, others have become enslaved by capture in the wars meanwhile going on, others by staking themselves in gaming, others by purchase, others by crime, others by debt. And of necessity the possession of many slaves, habitually accompanying wealth and power, tends still further to increase that wealth and power, and to mark off still more the higher rank from the lower.

Certain concomitant influences generate differences of nature, physical and mental, between those members of a community who have at-

tained superior positions, and those who have remained inferior. Unlikenesses of *status* once initiated lead to unlikenesses of life, which, by the constitutional changes they work, presently make the unlikenesses of *status* more difficult to alter.

First there comes difference of diet and its effects. In the habit, common among primitive tribes, of letting the women subsist on the leavings of the men, and in the accompanying habit of denying to the younger men certain choice viands which the older men eat, we see exemplified the inevitable proclivity of the strong to feed themselves at the expense of the weak; and, when there arise class-divisions, there habitually results better nutrition of the superior than of the inferior. Forster remarks that in the Society Islands the lower classes often suffer from a scarcity of food which never extends to the upper classes. In the Sandwich Islands the flesh of such animals as they have is eaten principally by the chiefs. Of cannibalism among the Feejeeans, Seeman says, "The common people throughout the group, as well as women of all classes, were by custom debarred from it." These instances sufficiently indicate the contrast that everywhere arises between the diets of the ruling few and of the subject many. And then by such differences of diet, and accompanying differences in clothing, shelter, and strain on the energies, are eventually produced physical differences. Of the Feejeeans we read that "the chiefs are tall, well made, and muscular; while the lower orders manifest the meagerness arising from laborious service and scanty nourishment." The chiefs among the Sandwich-Islanders "are tall and stout, and their personal appearance is so much superior to that of the common people that some have imagined them a distinct race." Ellis, verifying Cook, says of the Tahitians, that the chiefs are, "almost without exception, as much superior to the peasantry . . . in physical strength as they are in rank and circumstances"; and Erskine notes a parallel contrast among the Tongans. That the like holds among the African races may be inferred from Reade's remark that "the court lady is tall and elegant; her skin smooth and transparent; her beauty has stamina and longevity. The girl of the middle classes, so frequently pretty, is very often short and coarse, and soon becomes a matron; while, if you descend to the lower classes, you will find good looks rare, and the figure angular, stunted, sometimes almost deformed."*

Simultaneously there arise, between the ruling and subject classes, unlikenesses of bodily activity and skill. Occupied, as those of higher rank commonly are, in the chase when not occupied in war, they have a life-long discipline of a kind conducive to various physical superiorities; while, contrariwise, those occupied in agriculture, in carrying of burdens, and in other drudgeries, partially lose what agility and ad-

* While writing, I find in the recently issued "Transactions of the Anthropological Institute" proof that, even now in England, the professional classes are both taller and heavier than the artisan classes.

dress they naturally had. Class-predominance is, therefore, thus further facilitated.

And then there are the respective mental traits produced by daily exercise of power, and by daily submission to power. The ideas, and sentiments, and modes of behavior, perpetually repeated, generate on one side an inherited fitness for command, and on the other side an inherited fitness for obedience; with the result that, in course of time, there arises on both sides the belief that the established relations of classes are the natural ones.

By implying habitual war among settled societies, the foregoing interpretations have implied the formation of compound societies. The rise of such class-divisions as have been described is, therefore, complicated by the rise of further class-divisions determined by the relations from time to time established between those conquerors and conquered whose respective groups already contain class-divisions.

This increasing differentiation which accompanies increasing integration is clearly seen in certain semi-civilized societies, such as that of the Sandwich-Islanders. Ellis enumerates their ranks as—"1. King, queens, and royal family, along with the councilor or chief minister of the king. 2. The governors of the different islands, and the chiefs of several large divisions. Many of these are descendants of those who were kings of the respective islands in Cook's time, and until subdued by Kamehameha. 3. Chiefs of districts or villages, who pay a regular rent for the land, cultivating it by means of their dependents, or letting it out to tenants. This rank includes also the ancient priests. 4. The laboring classes—those renting small portions of land, those working on the land for food and clothing, mechanics, musicians, and dancers." And, as shown by other passages, the laboring classes here grouped together are divisible into—artisans, who are paid wages; serfs, attached to the soil; and slaves. Inspection makes it tolerably clear that the lowest chiefs, once independent, were reduced to the second rank when adjacent chiefs conquered them and became local kings; and that they were reduced to the third rank at the same time that these local kings became chiefs of the second rank, when, by conquest, a kingship of the whole group was established. Other societies in kindred stages show us kindred divisions similarly to be accounted for. Among the New-Zealanders there are six grades; there are six among the Ashantees; there are five among the Abyssinians; and other more or less compounded African states present analogous divisions. Perhaps ancient Peru furnishes as clear a case as any of the superposition of ranks resulting from subjugation. The petty kingdoms which were massed together by the conquering Incas were severally left with the rulers and their subordinates undisturbed; but over the whole empire there was a superior organization of Inca rulers of various grades. That kindred causes produced kindred effects in

early Egyptian times is inferable from traditions and remains which tell us both of local struggles which ended in consolidation and of conquests by invading races; whence would naturally result the numerous divisions and subdivisions which Egyptian society presented: an inference justified by the fact that under Roman dominion there was a recomplication caused by superposing of Roman governing agencies upon native governing agencies. Passing over other ancient instances, and coming to the familiar case of our own country, we may note how, from the followers of the conquering Norman, there arose the two ranks of the greater and lesser barons, holding their land directly from the king, while the old English thanes were reduced to the rank of sub-feudatories. Of course, where perpetual wars produce, first, small aggregations, and then larger ones, and then dissolutions, and then reaggregations, and then unions of them, various in their extents, as happened in mediæval Europe, there result very numerous divisions. In the Merovingian kingdoms there were slaves having seven different origins; there were serfs of more than one grade; there were freedmen—men who, though emancipated, did not rank with the fully free; and there were two other classes less than free—the *liten* and the *coloni*. Of the free there were three classes—independent land-owners; freemen in relations of dependence with other freemen, of whom there were two kinds; and freemen in special relations with the king, of whom there were three kinds.

And here, while observing in these various cases how greater political differentiation is made possible by greater political integration, we may also observe that in early stages, while social cohesion is small, greater political integration is made possible by greater political differentiation. For the larger the mass to be held together, while incoherent, the more numerous must be the agents standing in successive degrees of subordination to hold it together.

The political differentiations which militancy originates, and which for a long time acquire increasing definiteness, so that intermixture of ranks by marriage is made a crime, are at later stages and under other conditions interfered with, traversed, and partially or wholly destroyed.

Where, throughout long periods and in ever-varying degrees, war has been producing aggregations and dissolutions, the continual breaking up and reforming of social bonds obscures the original divisions established in the ways described: instance the state of things in the Merovingian kingdoms just named. And where, instead of conquests by kindred adjacent societies, which in large measure leave standing the social positions and properties of the subjugated, there are conquests by alien races carried on more barbarously, the original grades may be practically obliterated, and in place of them there may arise grades originating entirely by appointment of the despotic conqueror. In parts of the East, where such overrunnings of race by race have

been going on from the earliest recorded times, we see this state of things substantially realized: there is little or nothing of hereditary rank, and the only rank recognized is that of official position. Besides the different grades of appointed state functionaries, there are no class distinctions, or none having political meanings.

A tendency to subordination of the original ranks and a substitution of new ranks is otherwise caused: it accompanies the progress of political consolidation. The change which has occurred in China well illustrates this effect. Gutzlaff says: "Mere title was afterward (on the decay of the feudal system) the reward bestowed by the sovereign, . . . and the haughty and powerful grandees of other countries are here the dependent and penurious servants of the Crown. . . . The revolutionary principle of leveling all classes has been carried in China to a very great extent. . . . This is introduced for the benefit of the sovereign, to render his authority supreme."

The causes of such changes are not difficult to see. In the first place, the subjugated local rulers losing, as integration advances, more and more of their power, lose, consequently, more and more of their actual if not of their nominal rank, passing from the condition of tributary rulers to the condition of subjects. Indeed, jealousy on the part of the monarch sometimes prompts positive exclusion of them from influential positions; as in France, where "Louis XIV systematically excluded the nobility from ministerial functions." Presently their distinction is further diminished by the rise of competing ranks created by state authority. Instead of the titles inherited by the land-possessing military chiefs, which were descriptive of their attributes and positions, there come to be titles conferred by the sovereign. Certain of the classes thus established are still of militant origin; as the knights made on the battle-field, sometimes in large numbers before battle, as at Agincourt, when five hundred were thus created, and sometimes afterward in reward for valor. Others of them arise from the exercise of political functions of different grades; as in France, where, in the seventeenth century, hereditary nobility was conferred on officers of the great council and officers of the chamber of accounts—officers who had habitually been of *bourgeois* extraction. The administration of law, too, presently originates titles of honor. In France, in 1607, nobility was granted to doctors, regents, and professors of law; and "the superior courts obtained, in 1644, the privileges of nobility of the first degree." "So that," as Warnkoenig remarks, "the original conception of nobility was in the course of time so much widened that its primitive relation to the possession of a fief is no longer recognizable, and the whole institution seems changed." These, with kindred instances, which our own country and other European countries furnish, show us both how the original class-divisions become blurred and how the new class-divisions are distinguished by being delocalized. They are strata which run through the integrated society,

having, many of them, no reference to the land, and no more connection with one place than another. It is true that, of the titles artificially conferred, the higher are habitually derived from the names of districts and towns: so simulating, but only simulating, the ancient feudal titles expressive of actual lordship over territories. The other modern titles, however, which have arisen with the growth of political, judicial, and other functions, have not even nominal references to localities. This change naturally accompanies the growing integration of the parts into a whole, and the rise of an organization of the whole which disregards the divisions among the parts.

More effective still, in weakening those primitive political divisions initiated by militancy, is increasing industrialism. This acts in two ways, firstly, by creating a class having power derived otherwise than from territorial possessions or official position; and, secondly, by generating ideas and sentiments at variance with the ancient assumptions of class-superiority. As we have already seen, rank and wealth are at the outset habitually associated. Existing uncivilized people still show us this relation. The chief of a kraal among the Koranna Hottentots is "usually the person of greatest property." In the Bechuana language "the word *kosi* . . . has a double acceptation, denoting either a chief or a rich man." Such small authority as a Chinook chief has, "rests on riches, which consists in wives, children, slaves, boats, and shells." So was it originally in Europe. In ancient Spain the title *ricos hombres*, applied to the barons, definitely identified the two attributes. Indeed, it is manifest that before the development of commerce, and while possession of land could alone give largeness of means, lordship and riches were directly connected; so that, as Sir Henry Maine remarks, "the opposition commonly set up between birth and wealth, and particularly wealth other than landed property, is entirely modern." When, however, with the arrival of industry at that stage in which wholesale transactions bring large profits, there arise traders who vie with, and exceed, many of the landed nobility in wealth, and when, by conferring obligations on kings and nobles, such traders gain social influence, there comes an occasional removal of the barrier between them and the titled classes. In France the progress began as early as 1271, when there were issued letters ennobling Raoul, the goldsmith—"the first letters conferring nobility in existence." The precedent, once established, is followed with increasing frequency, and sometimes, under pressure of financial needs, there grows up the practice of selling titles, in disguised ways or openly. In France, in 1702, the king ennobled two hundred persons at three thousand livres a head; in 1706, five hundred at six thousand a head. And then, the breaking down of the ancient political divisions thus caused, is furthered by that weakening of them consequent on the growing spirit of equality fostered by industrial life. In proportion as men are daily habituated to maintain their own claims while respecting the claims of others, which

they do in every act of exchange, whether of goods for money or of services for pay, there is produced a mental attitude at variance with that which accompanies subjection; and, as fast as this happens, such political distinctions as imply subjection lose more and more of that respect which gives them strength.

Class-distinctions, then, date back to the beginnings of social life. Omitting those small wandering assemblages which are so incoherent that their component parts are ever changing their relations to one another and to the environment we see that, wherever there is some coherence and some permanence of relation among the parts, there begin to arise political divisions. Relative superiority of power, first causing a differentiation at once domestic and social, between the activities and positions of the sexes, presently begins to cause a differentiation among males, shown in the bondage of captives; a master-class and a slave-class are formed.

Where men continue the wandering life in pursuit of wild food for themselves or their cattle, the groups they form are debarred from doing more by war than appropriate one another's units individually; but, where men have passed into the agricultural or settled state, it becomes possible for one community to take possession bodily of another community, along with the territory it occupies. When this happens, there arise additional class-divisions. The conquered and tribute-paying community, besides having its head-men reduced to subjection, has its people reduced to a state such that, while they continue to live on their lands, they yield up, through the intermediation of their chiefs, part of the produce to the conquerors; so foreshadowing what eventually becomes a serf-class.

From the beginning the militant class, being by force of arms the dominant class, becomes the class which owns the source of food—the land. During the hunting and pastoral stages, the warriors of the group hold the land collectively. On passing into the settled state, their tenures become partly collective and partly individual in sundry ways, and eventually almost wholly individual. But, throughout long stages of social evolution, land-owning and militancy continue to be associated.

The class-differentiation, of which militancy is the active cause, is furthered by the establishment of definite descent, and especially male descent, and the transmission of position and property to the eldest son of the eldest continually. This conduces to inequalities of position and wealth between near kindred and remote kindred; and such inequalities of wealth, once initiated, strengthen themselves by giving to the superior increased means of maintaining their power by accumulating appliances for offense and defense.

Such differentiation is increased, at the same time that a new differentiation is initiated, by the immigration of fugitives who attach

themselves to the most powerful member of the group, now as dependents who work, and now as armed followers—armed followers who form a class bound to the dominant man, and unconnected with the land. And since, in clusters of such groups, fugitives ordinarily flock most to the strongest group, and become adherents of its head, they are instrumental in furthering those subsequent integrations and differentiations which conquests bring about.

Inequalities of social position, bringing inequalities in the supplies and kinds of food, clothing, and shelter, tend to establish physical differences, to the further advantage of the rulers and disadvantage of the ruled. And, beyond the physical differences, there are produced, by the respective habits of life, mental differences, emotional and intellectual, strengthening the general contrast of nature.

When there come the conquests which produce compound societies, and, again, doubly compound ones, there come superpositions of ranks. And the general effect is that, while the ranks of the conquering society become respectively higher than those which existed before, those of the conquered become respectively lower.

The class-divisions thus formed during the earlier stages of militancy are traversed and obscured as fast as the many small societies are consolidated into one large society. Ranks referring to local organization are gradually replaced by ranks referring to general organization. Instead of deputy and sub-deputy governing agents who are the militant owners of the subdivisions they rule, there come governing agents who more or less clearly form strata running throughout the society as a whole—a concomitant of developed political administration.

Chiefly, however, we have to note that, while the higher political evolution of large social aggregates tends to break down the divisions of rank which grew up in the small component social aggregate, by substituting other divisions, these original divisions are still more broken down by growing industrialism. Generating a wealth that is not connected with rank, this initiates a competing power; and at the same time, by establishing the equal positions of citizens before the law in respect of trading transactions, it weakens those divisions which at the outset expressed inequalities of position before the law.

As verifying these interpretations, I may add that they harmonize with the interpretations of ceremonial institutions recently given. As the primary differences of rank result from victories, and as the primary forms of propitiation originate in the behavior of the vanquished to the vanquishers, so the later differences of rank result from differences of power which, in the last resort, express themselves in physical coercion, and so the observances between ranks are recognitions of such differences of power. When the conquered enemy is made a slave, and mutilated by taking a trophy from his body, we see simultaneously originating the deepest political distinction and the cere-

mony which marks it; and, with the continued militancy that compounds and recompounds social groups, there goes at once the development of political distinctions and the development of ceremonies marking them. And, as we before saw that growing industrialism diminishes the rigor of ceremonial rule, so here we see that it tends to destroy those class-divisions which militancy originates, and to establish others which indicate differences of position consequent on differences of aptitude for the various functions which an industrial society needs.

ORIGIN OF THE PLOW AND WHEEL-CARRIAGE.

By E. B. TYLOR, F. R. S.

THOUGH much has been written on that great engine of civilization, the plow, yet the whole line of evidence as to its development from the simplest and earliest agricultural implements seems never to have been put together, so that I venture to lay before the Anthropological Institute the present notes.

Not only the beginning of agriculture, but the invention of the plow itself, is prehistoric. The plow was known to the ancient Egyptians and Babylonians, and the very existence of these nations points to previous thousands of years of agricultural life, which alone could have produced such dense, settled, and civilized populations. It was with a sense of what the plow had done for them that the old Egyptians ascribed its invention to Osiris, and the Vedic bards said the Açvins taught its use to Manu, the first man. Many nations have glorified the plow in legend and religion, perhaps never more poetically than where the Hindoos celebrate *Sítá*, the spouse of Râma, rising brown and beauteous, crowned with corn-ears, from the plowed field; she is herself the furrow (*sîtâ*) personified. Between man's first rude husbandry and this advanced state of tillage lies the long interval which must be filled in by other than historical evidence. What has first to be looked for is hardly the actual invention of planting, which might seem obvious even to rude tribes who never practice it. Every savage is a practical botanist, skilled in the localities and seasons of all useful plants, so that he can scarcely be ignorant that seeds or roots, if put into proper places in the ground, will grow. When low tribes are found not tilling the soil, but living on wild food, as apparently all mankind once did, the reason of the absence of agriculture would seem to be not mere ignorance, but insecurity, roving life, unsuitable climate, want of proper plants, and, in regions where wild fruits are plentiful, sheer idleness and carelessness. On looking into the condition of any known savage tribes, Australians, Andamaners, Botocudos, Fuegians, Esquimaux, there is always one or more of these reasons to account for

want of tillage. The turning-point in the history of agriculture seems to be not the first thought of planting, but the practical beginning by a tribe settled in one spot to assist nature by planting a patch of ground round their huts. Not even a new implement is needed. Wandering tribes already carry a stick for digging roots and unearthing burrowing animals, such as the *katta* of the Australians, with its point hardened in the fire (Fig. 1), or the double-ended stick which

Fig. 1.—Australian "Katta."

Dobrizhoffer ("Abipones," part ii, chap. xiii) mentions as carried by the Abipone women to dig up eatable roots, knock down fruits or dry branches for fuel, and even, if need were, break an enemy's head with. The stick which dug up wild roots passes to the kindred use of planting, and may be reckoned as the primitive agricultural implement. It is interesting to notice how the Hottentots in their husbandry break up the ground with the same stone-weighted stick they use so skillfully in root-digging or unearthing animals (J. G. Wood, "Natural History of Man," vol. i, p. 254.) The simple pointed stake is often mentioned as the implement of barbaric husbandry, as when the Kurubars of south India are described as with a sharp stick digging up spots of ground in the skirts of the forest, and sowing them with ragy (Buchanan, "Journey through Mysore, etc.," in Pinkerton, vol. viii, p. 707); or where it is mentioned that the Bodo and Dhimál of north-east India, while working the ground with iron bills and hoes, use a four-foot two-pointed wooden staff for a dibble (B. H. Hodgson, "Aborigines of India," p. 181). The spade, which is hardly to be reckoned among primitive agricultural implements, may be considered as improved from the digging-stick by giving it a flat, paddle-like end, or arming it with a broad, pointed metal blade, and afterward providing a foot-step (see the Roman spade in Smith's "Dictionary of Greek and Roman Antiquities," s. v. "pala"). In the Hebrides is to be seen a curious implement called *caschrom*, a kind of heavy bent spade with an iron-shod point, which has been set down as a sort of original plow (Rau, "Geschichte des Pflugs," p. 16; Macculloch, "Western Islands," Plate 30); but its action is that of a spade, and it seems out of the line of development of the plow. To trace this, we have to pass from the digging-stick to the hoe.

All implements of the nature of hoes seem derived from the pick or axe. Thus the New Caledonians are said to use their wooden picks both as a weapon and for tilling the ground (Klemm, "Culturwissenschaft," part ii, p. 78). The *tima*, or Maori hoe (Fig. 2), from R. Taylor's "New Zealand and its Inhabitants," p. 423, is a remarkable curved wooden implement in one piece. It is curious that of all this class of agricultural implements the rudest should make its appearance in

Europe. Tradition in south Sweden points to waste pieces of once-tilled land in the forests and wilds as having been the fields of the old "hackers," and within a generation there was still to be seen in use on forest farms the "hack" itself (Fig. 3), made of a stake of spruce-fir, with, at the lower end, a stout projecting branch cut short and pointed (Hyltén-Cavallius, "Wärend och Wirdarne," part ii, p. 110; i, p. 43). Even among native tribes of America a more artificial hoe than this was found in use. Thus the hoe used by the North American women in preparing the soil for planting maize, after the old stalks had been burned, is described as a bent piece of wood, three fingers wide, fixed to a long handle (see Charlevoix, "Nouvelle France," Letter 23; Lafitau, "Mœurs des Sauvages Ameriquains," vol. ii, p. 76, and Plate 7). (I do not venture to copy the hoe shown in this plate: a mere fancy picture.) In other North American tribes the women hoed with a shoulder-blade of an elk or buffalo, or a piece of the shell of a tortoise fixed to a straight handle (see Loskiel, "Mission of the United Brethren in North America," p. 66; Catlin, "American Indians," vol. i, p. 121). From this stage we come up to implements with metal

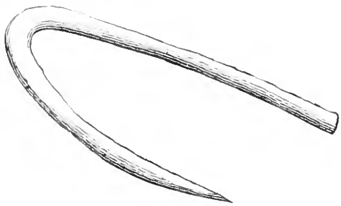


Fig. 2.—"Tima," or Maori Hoe.

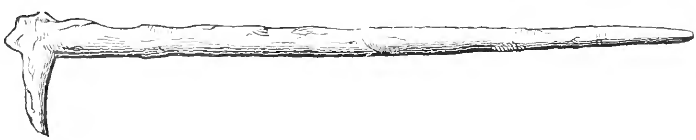


Fig. 3.—Swedish "Hack."

blades, such as the Caffre axe, which, by turning the blade in the handle, becomes an implement for hoeing (Lane Fox, "Lectures on Primitive Warfare," No. 2, p. 10). The heavy-bladed Indian hoe (Sanskrit, *kuddâla*), called *kodâly* in Malabar (Klemm, "Culturwissenschaft," part ii, p. 123), which is shown in Fig. 4, is one example of the iron-bladed hoe, of clumsy and ancient type. The modern varieties of the hoe need no detailed description here.

That the primitive plow was a hoe dragged through the ground to form a continuous furrow, is seen from the very structure of early plows, and was accepted as obvious by Ginzrot ("Wagen und Fahrwerke der Griechen und Römer," vol. i, and Klemm, "Culturwissenschaft," part ii, p. 78). The evidence of the transitions through which agricultural implements have passed in Sweden during the last ten centuries or so, which was unknown to these writers, is strongly confirmatory of the same view. It appears that the fir-tree hack (Fig. 3) was followed by a heavier wooden implement of similar shape, which

was dragged by hand, making small furrows; this "furrow-crook" is still used for sowing. Afterward was introduced the "plow-crook," made in two pieces, the share with the handle and the pole for drawing. The share was afterward shod with a three-cornered iron bill,

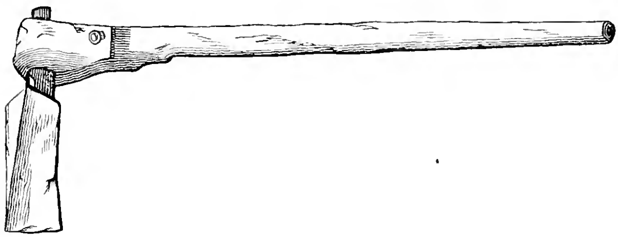
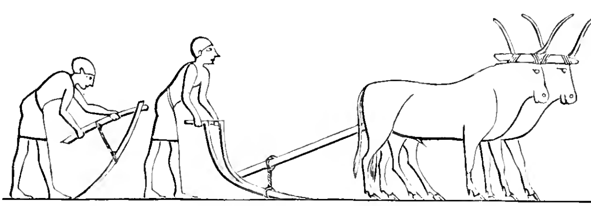


Fig. 4.—Indian Hoe.

but the implement was long drawn by hand, till eventually it came to be drawn by mares or cows (Hyltén-Cavallius, part ii, p. 111). Thus in comparatively modern times a transformation took place in Sweden remarkably resembling that of which we have circumstantial evidence as having happened in ancient Egypt. The Egyptian monuments show a plow, which was practically a great hoe, being dragged by a rope by men (see Denon, "Antiquités de l'Egypte," vol. i, Pl. 68). Still more perfect is the plowing scene here copied in Fig. 5 (see Rosellini, "Monumenti dell' Egitto," Pl. 32, 33; Wilkinson, "Ancient Egyptians," chap. vi). Here the man who follows the plow to break up the clods is working with the ordinary Egyptian hoe, remarkable for its curved wooden blade longer than the handle, and prevented

Fig. 5.



from coming abroad by the cord attaching the blade to the handle half-way down. This peculiar implement, with its cord to hold it together, reappears on a larger scale in the plow itself, where the straight stick is lengthened to form the pole by which the oxen draw it, and a pair of handles are added by which the plowman keeps down and guides the plow. The valley of the Nile, where the lightness and richness of the alluvial soil are favored by the inundations with their fresh deposit of river-mud, was no doubt one of the regions where the higher agriculture earliest arose, and, looking at this sketch of hoeing and plowing, we might be tempted to think that here the transition

from the barbaric hoe to the civilized plow is to be seen as it first took place in the world. Egypt may possibly have been the birthplace of the plow; but so many forms of rude plows are to be found represented on coins and sculptures of the ancient world, that it is safer to be content with the general idea that they are enlarged and transformed hoes, without attempting to fix the date, place, and nation to which this inventive transformation belongs. The following figures

Fig. 6.

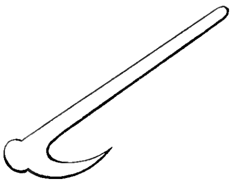


Fig. 7.

are selected from those copied by Ginzrot and Rau. The old Syracusan form (Fig. 6), as likewise some old Etruscan patterns, is remarkable as being so close to the original hoe pattern as not to have the tail or handle. This want is supplied in other rude forms of ancient Italy, of which Fig. 7 shows one. A more angular Roman form is thought to represent the ceremonial plow, with which the wall-line was traced in founding a new city, and Fig. 8 is another archaic form; the projection of the pole behind was for the plowman's foot to press the share down:

> "Depresso incipiat jam tum mihi taurus aratro
> Ingemere, et sulco attritus splendescere vomer."
> (Virgil, "Georgics," I, 45.)

Fig. 9 is Greek, from an early MS. of Hesiod's "Works and Days." Looking at forms of plow as rude as these to be seen at this day in Asia and in backward countries of Europe, one wonders to find that already in classic ages the husbandman had plows of construction far

Fig. 8.

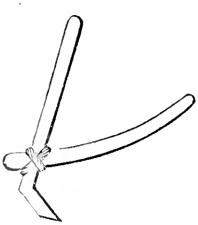
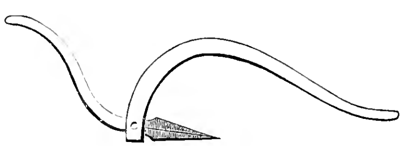


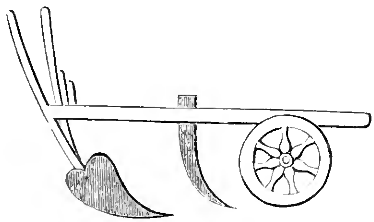
Fig. 9.



more nearly approaching that of our best modern implement-makers. Pliny (xviii, c. 48), after describing the simpler kinds of plow, mentions that in Rhætia a plow with the addition of two small wheels had

been recently invented, and was used for land already under tillage. He also mentions the coulter (*culter*). This knife, fixed in front to make the first cut ready for the share to turn the sod, is a great improvement on the primitive plows, where the plowshare has to do the whole work. In Pliny's time, though only forming part of some plows, it was evidently well known. Thus he recognizes the whole construction of the wheel-plow (Fig. 10) as figured by Caylus from an ancient gem. The ordinary modern plow used by the English farmer improves upon this rather in details of construction and material than in essential principle, though a new start in invention is taken by the self-acting plow, which no longer needs the plowman to follow at the plow-tail, and by the steam-plow, which substitutes engine-traction.

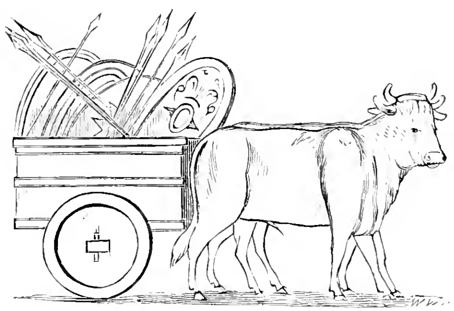
Fig. 10.



The plow, drawn by oxen or horses, and provided with wheels, has taken on itself the accessories of a wheel-carriage. But, when the plow is traced back to its earliest form of a hoe dragged by men, its nature has little in common with that of the vehicle. Though the origin of the wheel-carriage is even more totally lost in prehistoric antiquity than that of the plow, there seems nothing to object to the ordinary theoretical explanation (see Reuleaux, "Kinematics of Machinery," and others), that the first vehicle was a sledge dragged along the ground; that, when heavy masses had to be moved, rollers were put under the sledge, and that these rollers passed into wheels, forming part of the carriage itself. The steps of such a transition, with one notable exception which will be noticed, are to be actually found. The sledge was known in ancient Egypt (see the well-known painting from El Bersheh of a colossal statue being dragged by men with ropes on a sledge along a greased way, Wilkinson, "Ancient Egyptians," vol. iii). On mountain-roads, as in Switzerland, as well as on the snow in winter, the sledge remains an important practical vehicle. The use of rollers under the sledge was also familiar to the ancients (see the equally well-known Assyrian sculpture of the moving of the winged bull, in Layard's "Nineveh and Babylon," p. 110). If, now, the middle part of the trunk of a tree used as a roller were cut down to a mere axle, the two ends remaining as solid drums, and stops were fixed under the sledge to prevent the axle from running away, the result would be the rudest imaginable cart. I am not aware that this can be traced anywhere in actual existence, either in ancient or modern times; if found, it would be of much interest as vouching for this particular stage of invention of the wheel-carriage. But the stage which would be theoretically the next improvement is to be traced in practical use;

this is to saw two broad drums off a tree-trunk, and connect them by a stout bar through their centers, pinned fast, so that the whole turns as a single roller. The solid drum-wheel was used in the farm-carts of classic times (see the article "Plaustrum," by Yates, in Smith's "Dictionary of Greek and Roman Antiquities"). The ox-wagon here shown is taken from the Antonine column (Fig. 11); it appears to have solid wheels, and the square end of the axle proves that it and its drum-wheels turned round together in one. A further improvement was to make the wheel with several pieces nailed together, which would be less liable to split. The ancient Roman farm-carts were mostly made with such wheels, as are their successors which are used to this day with wonderfully little change, as in Greece and Portugal.

Fig. 11.

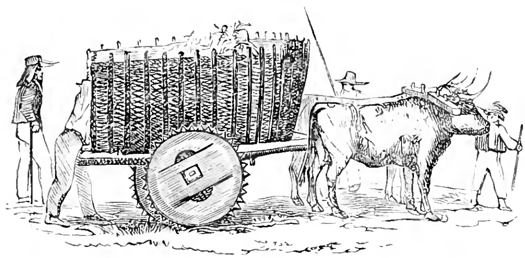


The bullock-cart of the Azores (Fig. 12) (from Bullar, "Winter in the Azores," vol. i, p. 121) is a striking relic from the classic world; its wheels are studded with huge iron nails, by way of tire. From old times it was common to make wooden rings, sockets, or bearings underneath the cart for the axle to turn in, much as children's toy-carts are made, as has often been remarked. But a drawing of a modern bullock-cart, taken near Lisbon, represents only a pair of pieces of wood acting as stops, so that the body of the cart can be lifted off its wheels. In looking at these clumsy vehicles, we certainly seem to have primitive forms before us. There is, however, the counter-argument, which ought not to be overlooked, and which in some measure accounts for the lasting-on of these rude carts, namely, that for heavy carting across rough ground they are convenient, as well as cheap and easily repaired. Considering that the railway-carriage builder gives up the coach-wheel principle, and returns to the primitive construction of the pair of wheels fixed to the axle turning in bearings, we see that our ordinary carriage-wheels turning independently on their axles are best suited to comparatively narrow wheels, and to smooth ground or made roads. Here they give greater lightness and speed, and especially have the advantage of easily changing direction and turning, which in

the old block-wheel cart can only be done by gradually slewing round in a wide circuit.

As early as history goes back, the carriage-builder had already begun to make spoked wheels with metal tires, whose well-made nave turned smoothly on the axle. It is needless here to extract from Wilkinson and Layard particulars of the beautifully made Egyptian and Assyrian chariots, nor to go into details of classic, mediæval, and modern carriage-building. As bearing on the origin of the art, it must be noticed that the point where the developments of the plow and car-

Fig. 12.



riage join is in the way of attaching the drawing oxen or horses, which was much alike in both. The pole and yoke was no doubt the original mode of draught, not only for the plow and the heavy ox-cart, where it may be often seen still, but also for the chariot and light car (see Schlieben, "Die Pferde des Alterthums," p. 154). The war-chariot, with its yoked steeds, has a remarkable similarity wherever we meet with it in the ancient world, which seems to point to its invention by some one particular nation, though which has not yet been made out, whence it spread to distant countries. How such inventions found their way is well shown in a point of detail, which incidentally shows how far the ancient Britons were from the uncivilized state popularly attributed to them, namely, their use (Mela iii, 6) of scythe-chariots, such as were used in Oriental armies, like that of Darius (Diod. Sic. xvii, 53), or of Antiochus Eupator, when he came into Judea with horsemen and elephants and three hundred scythe-chariots (2 Maccab. xiii, 2). War-chariots were from the first drawn by the pole. The Homeric chariots appear to have been without traces, as where, in the Iliad (vi, 40), Adrastus's scared horses snap the pole amid the tangled tamarisk, and set off straight for the city, evidently having nothing but the pole to hold them. In ancient Egypt, one inner trace was used, but the stress was on the pole. Eventually, in looking at the harness of various nations, we come to the present plan of draught by collar and traces. The change is interesting, as seeming to prove that the earliest use of draught-cattle is that still seen in the yoke of oxen. It has been argued by Pictet ("Origines Indo-Européennes," part ii, p.

94) that the yoke, Sanskrit, *yuga* = that which *joins*, was first invented for the pair of oxen to draw the plow with, it being likely that they were first put to this heavy work, and afterward used for drawing carts, rather than that the idea of drawing a cart by oxen should have occurred before putting them to plow. This, though not absolutely certain, seems a very reasonable argument; while the yoke and pole, being so much better suited to the ox than to the horse, point to oxen as the earliest draught-beasts. The history of successive changes seems well shown in the Latin *jumentum*, a beast of burden, from *jugumentum* = yoke-ment, which word keeps up the memory of the original yoke, though other modes of transporting burdens had come in. The Latin *jumentum* is used for the horse, etc., but not for the ox; and French *jument* has still further lost the old idea, now meaning merely a mare. One further remark is suggested by the harness of the ancient Egyptian chariot, where the yoke is provided with two saddles coming down on the withers of the horses. As is well known, cavalry was by no means general among the armies of the ancient world. The early Aryans, like the Homeric heroes, were charioteers, not horsemen, nor are there any ancient Egyptian horsemen to be seen on the monuments. On the other hand, the warriors of Palestine are there to be seen on horseback, and horse-soldiers appear on the Assyrian sculptures. In old times, however, the horseman is mostly seen riding a barebacked horse, or with a cloth or pad only. It seems to have been gradually that saddles proper began to be used in Assyria, and among the Greeks and Romans. Looking, now, at the Egyptian yoke-saddles of the chariots, one may suspect that from them were derived not only the harness-saddles in modern use, but also our riding-saddles.—*Journal of the Anthropological Institute.*

PHYSICAL EDUCATION.

By FELIX L. OSWALD, M. D.

DIET (*continued*).

BUT, under all circumstances, make a firm stand against the POISON-HABIT. It is best to call things by their right names. The effect upon the animal economy of every stimulant is strictly that of a poison, and every poison may become a stimulant. There is no bane in the South American swamps, no virulent compound in the North American drug-stores—chemistry knows no deadliest poison—whose gradual and persistent obtrusion on the human organism will not create an unnatural craving after a repetition of the lethal dose, a morbid appetency in every way analogous to the hankering of the toper after his favorite

tipple. Swallow a tablespoonful of laudanum or a few grains of arsenious acid every night: at first your physical conscience protests by every means in its power; nausea, gripes, gastric spasms, and nervous headaches warn you again and again; the struggle of the digestive organs against the fell intruder convulses your whole system. But you continue the dose, and Nature, true to her highest law to preserve life at any price, finally adapts herself to an abnormal condition—adapts your system to the poison at whatever cost of health, strength, and happiness. Your body becomes an opium-machine, an arsenic-mill, a physiological engine moved by poison, and performing its vital functions only under the spur of the unnatural stimulus. But by and by the jaded system fails to respond to the spur, your strength gives way, and, alarmed at the symptoms of rapid *deliquium*, you resolve to remedy the evil by removing the cause. You try to renounce stimulation, and rely once more on the unaided strength of the *vis vitæ*. But that strength is almost exhausted. The oil that should have fed the flame of life has been wasted on a health-consuming fire. Before you can regain strength and happiness, your system must *readapt* itself to the normal condition, and the difficulty of that rearrangement will be proportioned to the degree of the present disarrangement; the further you have strayed from Nature, the longer it will take you to retrace your steps. Still, it is always the best plan to make your way back somehow or other, for, if you resign yourself to your fate, it will soon confront you with another and greater difficulty. Before long the poison-fiend will demand a larger fee; you have to increase the dose. The "delightful and exhilarating stimulant" has palled, the *quantum* has now to be doubled to pay the blue-devils off, and to the majority of their distracted victims that seems the best, because the shortest, road to peace. Restimulation really seems to alleviate the effects of the poison-habit for a time. The anguish always returns, and always with increased strength, as a fire, smothered for a moment with *fuel*, will soon break forth again with a fiercer flame.

By these symptoms the disease of the poison-habit may be identified in all its disguises, for the self-deception of the poor lady who seeks relief in a cup of the same strong tea that has caused her sick-headache is absolutely analogous to that of the pothouse sot who hopes to drown his care in the source of all his misery, or of the frenzied opium-eater who tries to exorcise a legion of fiends with the aid of Beelzebub. There are few accessible poisons which are not somewhere abused for the purpose of intoxication: the Guatemala Indians fuddle with hemlock-sap, the Peruvians with *coca*, the Tartars with fermented mare's milk, the Algerians with hasheesh; but, wherever men have dealings with the "fiend that steals away their brains," there are always Ancient Iagos who mistake him for a "good familiar creature," till he steals their health and wealth as well as their wits. Their woes are not the penalty of their persistent blindness, but of their first open-

eyed transgression. There is a Spanish proverb to the effect that it is easier to keep the devil out than to turn him out, and many dupes of the Good Familiar would actually think it an ingratitude to turn him off; but they should have known better than to admit him when he presented himself with horns and claws. To a normal taste every poison is abhorrent, and with the rarest exceptions the degree of the repulsiveness is proportioned to that of the virulence. In the mouth of a healthy child, rum is a liquid fire; beer, an emetic; tea and coffee, bitter decoctions; tobacco-fumes revolt the stomach of the non-*habitué*. Only blind deference to the example of his elders will induce a boy to accustom himself to such abominations; if he were left to the guidance of his natural instincts, intoxication would be anything but an insidious vice.

With all its ramifications, the poison-habit is a upas-tree which has polluted the well-springs and tainted the very atmosphere of our social life. The woe which the human race owes to alcohol alone is so far beyond description that I will here only record my belief that its total interdiction will form the first commandment in the decalogue of the future. The power of prejudice has its limits. No man, possessed of a vestige of common sense, can read the scientific literature that has accumulated upon the subject, and doubt that even the moderate use of distilled liquors as a beverage amply justifies the belief in the existence of unqualified evils. The effects of tea and coffee drinking are also well understood, but I must call attention to an often overlooked though most important feature of the habit—its progressiveness. The original moderate *quantum* soon palls, and it is this craving of the system *for the same degree of stimulation* which leads us to Johnsonian excesses or to the adoption of a stronger stimulant. Men generally prefer the latter alternative. Coffee, tea, and tobacco pave the way to opium in the East and to alcohol in the West. The same holds true of pungent spices. Pepper and mustard form the vanguard of the poison-fiend. They inflame the liver, produce a morbid irritability of the stomach, cause numerous functional derangements by impeding the process of assimilation, and thus become auxiliary in expediting the development of the poison-habit. Whatever irritates the digestive organs or unusually exhausts the vital forces tends to the same effect. Besides, they blunt the susceptibility of the gustatory nerves, and thus diminish our enjoyment of the simple viands that should form our daily food. In trying to heighten that enjoyment, the surfeited gastronome defeats his own purpose: all sweetmeats pall; the most appetizing dishes he values only as a foil to his caustic condiments, like the Austrian peddler who trudges through the flower-leas of the Alpenland in a cloud of nicotine, and to whom the divine afflatus of the morning wind is only so much draught for his tobacco-pipe.

With a single and not quite explained exception, man is the only animal that resorts to stimulation: a few ruminant mammals—cows,

sheep, and deer—pay an occasional visit to the next salt-lick. The carnivora digest their meat without salt; our next relatives, the frugivorous four-handers, detest it. Not one of the countless tonics, cordials, stimulants, pickles, and spices, which have become household necessities of modern civilization, is ever touched by animals in a state of nature. A famished wolf would shrink from a "deviled gizzard." To children and frugivorous animals our pickles and pepper-sauces are, on the whole, more offensive than meat, and therefore, probably more injurious. To savages, too. In the summer of 1875 I stood one evening near the quartermaster's office at Fort Wingate, New Mexico, when two Kiowa Indians applied for permission to water their famished horses at the Government cistern, offering to accept that boon in part payment of a load of brushwood which they proposed to haul from the neighboring *chaparral*. The fellows looked thirsty and hungry themselves, and, while the quartermaster ratified the wood-bargain, one of the officers sent to his company quarters for a lunch of such comestibles as the cooks might have on hand at that time of the day. A trayful of "Government grub" was deposited on the adjacent cord-wood platform, and the Indios pitched in with the peculiar appetite of carnivorous nomads. A yard of commissary sausage was accepted as a tough variety of jerked beef; yeasted and branless bread disappeared in quantities that would have confirmed Dr. Graham's belief in natural depravity; they sipped the cold coffee and eyed it with a gleam of suspicion, but were reconciled by the discovery of the saccharine sediment, and the cook was just going to replenish their cups when the senior Kiowa helped himself to a vinegar pickle, which he probably mistook for some sort of an off-color sugar-plum. He tasted it, rose to his feet, and dashed the plate down with a muttered execration, and then clutched the prop of the platform to master his rising fury. Explanations followed, and a pound of brown sugar was accepted as a peace-offering, but the children of Nature left the post under the impression that they had been the victims of a heartless practical joke. "D—n their breechless souls, they don't know what's good for them!" was the cook's comment, which I should endorse if his guests had been in need of a blister. A slice of a peppered and allspiced vinegar pickle will blister your skin as quick as a plaster of Spanish flies. The lady-friends of Dio Lewis have promised us an "Art of Cookery for Total Abstainers," and, if the book should correspond to the title, I would suggest a motto: "No spice but hunger; no stimulant but exercise."

By avoiding pungent condiments we also obviate the *principal cause of gluttony*. It is well known that the admirers of lager-beer do not drink it for the sake of its nutritive properties, but as a medium of stimulation, and I hold that nine out of ten gluttons swallow their peppered *ragoûts* for the same purpose. Only natural appetites have natural limits. Two quarts of water will satisfy the normal thirst of

a giant, two pounds of dates his hunger after a two days' fast. But the beer-drinker swills till he runs over, and the glutton stuffs himself till the oppression of his chest threatens him with suffocation. Their unnatural appetite has no limits but those of their abdominal capacity. *Poison-hunger* would be a better word than appetite. What they really want is alcohol and hot spices, and, being unable to swallow them "straight," the one takes a bucketful of swill, the other a potful of grease into the bargain.

But gluttony has one other cause—involuntary cramming. Fond mothers often surfeit their babies till they sputter and spew, and it is not less wrong to force a child to eat any particular kind of food against his grain—in disregard of a natural antipathy. Such aversions are allied to the feeling of repletion by which Nature warns the eater to desist, and, if this warning is persistently disregarded, the monitory instinct finally suspends its function ; overeating becomes a morbid habit, our system has adapted itself to the abnormal condition, and every deviation from the new routine produces the same feeling of distress which shackles the rum-drinker to his unnatural practice. Avoid pungent spices, do not cram your children against their will, and never fear that natural aliments will tempt them to excess. But I should add here that of absolutely innocuous food—ripe food and simple farinaceous preparations—a larger quantity than is commonly imagined can be habitually taken with perfect freedom from injurious consequences. On the Upper Rhine they have *Trauben-Curen*—sanitaria where people are fed almost exclusively on ripe grapes in order to purify their blood. The grapes generally used for this purpose are of the variety known as Muskateller, with big, honey-sweet berries of a most enticing flavor. "Doesn't such physic tempt your patients?" I asked the manager of a famous Trauben-Cure ; "don't they dose themselves to a damaging extent?" His answer surprised me. "Damaging? Yes, sir," said he, "they damage my pocket, some of them do, though I charge them three florins a day, lodgers five. They can not damage *themselves* by eating Muskateller."

Never stint the supply of fresh drinking-water. The danger of water-drinking in warm weather has been grossly exaggerated. Cold water and cold air are the two scapegoats that have to bear the burden of our besetting sins. There is, indeed, something preposterous in the idea that Nature would punish us for indulging a natural appetite to its full extent. Sheep that have been fed on dry corn-husks all winter sometimes break into a clover-field and eat till they burst ; but who ever heard of a dyspeptic bear, or of an elk prostrated by a fit of gastric spasms? And yet we need not doubt that wild animals eat while their appetite lasts. If we lock them up and deprive them of their wonted exercise, their appetite, too, diminishes. In short, as long as we confine ourselves to our proper diet, our stomachs never call for more than we can digest. There are things that have to be eaten

in homœopathic doses to prevent surfeit, but respecting such stuff (Limburger, caviare, etc., I would say, as of spices and alcohol), abstinence is better than temperance. In convivial neighborhoods sporadic cases of surfeit are almost as unavoidable as Christmas dinners and school picnics; but their effects are as transient as their causes. For children, a nearly infallible peptic corrective is a *fast day passed in cheerful out-door exercise.* By a curious law of periodicity, the mind will stray to the dining-room when the wonted meal-time comes around, even if genuine appetite does not return with that hour, but fishing, hunting, and ball-playing divert our thoughts from such channels, and, returning late in the evening from a good day's sport, the periodicity of bedroom-thoughts, aided by fatigue, overcomes the latent craving for food without the least effort. Try the experiment.

Want of appetite is not always a morbid symptom, nor even a sign of imperfect digestion. Nature may have found it necessary to muster all the energies of our system for some special purpose, momentarily of paramount importance. Organic changes and repairs, teething, pleuritic epurations, and the external elimination of bad humors (boils, etc.), are often attended with a temporary suspension of the alimentary process. The instinct of domestic animals thus generally counteracts the influence of abnormal circumstances. As a rule, it is always the safest plan to give Nature her own way, and was thus proved even in the extreme cases of more than one *bona fide* fasting girl, whose system, for recondite reasons of its own, preferred to subsist on air for weeks and months together.

In regard to the quality of food, too, there are intuitive dislikes which should not be disregarded, because they can not always be accounted for. I do not say *likes and* dislikes; a child's whimsical desire to treat innutritious or injurious substances as comestibles should certainly not be encouraged as long as its hunger can be appeased with less suspicious aliments. For it is a curious fact that *all* unnatural practices—the eating of indigestible matter as well as of poisons—are apt to excite a morbid appetency akin to the stimulant habit. The human stomach can be accustomed to the most preposterous things. The Otomacs, of South America, whose forefathers in times of scarcity may have filled their bellies with loam, are now afflicted with a national *penchant* for swallowing inorganic substances. In New Caledonia, *habitués* often eat as much as two pounds of ferruginous clay a day, and a similar stuff is sold in the markets of Bolivia, and finds eager purchasers, even when better comestibles are cheaper. Professor Ehrenberg procured a sample of this clay which was supposed to contain organic admixtures or some kind of fat; but his analysis proved that it consists of talc, mica, and a little oxide of iron. According to Malte-Brun, the Lisbon lazzaroni chew all day long the insipid, leathery kernels of the carob-bean (*Mimosa silica*), and the most popular "chewing-gum" is said to be composed chiefly (not entirely, I

hope) of resin, paraffine, and triturated caoutchouc! Still, Ehrenberg's analysis makes stranger things credible. I do not doubt that a man might contract a habit of swallowing a couple of slate-pencils or a dime's worth of shoe-strings every morning.

But an innate *repugnance* to a special dish, or even to a special class of aliments, may be indulged very cheaply, and certainly very safely, as long as there are other available substances of the same nutritive value. Abnormal antipathies may indicate constitutional abnormities, and among the curious cases on record there are some which clearly preclude the idea of imaginative influences. I knew a Belgian soldier on whom common salt, in any combination, and in any dose exceeding ten pennyweights, acted as a drastic poison, and thousands of Hindoos can not taste animal food without vomiting. Similar effects have obliged individuals to abstain from onions, sage, parsnips, and even from Irish potatoes. Dr. Pereira mentions the case of an English boy who had an incurable aversion to mutton: "He could not eat mutton in any form. The peculiarity was supposed to be owing to caprice, but the mutton was repeatedly disguised and given to him unknown; but uniformly with the same result of producing violent vomiting and diarrhœa. And from the severity of the effects, which were in fact those of a virulent poison, there can be little doubt that, if the use of mutton had been persisted in, it would soon have destroyed the life of the individual." *

It may be considered as a suggestive circumstance that the great plurality of such instinctive aversions relate either to stimulants or to some kind of animal food. To one person whose stomach can not bear bread or apples, we shall find a thousand with an invincible repugnance to pork, coffee, and pungent condiments. It is also certain that, by voluntary abstinence from all such things, the vigor of the alimentary organs can be considerably increased. The Danish sailors whom the Dey of Algiers had fed on barley and dates for a couple of months, found that after that they "could digest almost anything." †

By adopting an absolutely non-stimulating, chiefly vegetable diet, combined with active exercise in open air, the most dyspeptic glutton can cure himself in the course of a single season, and by the same means every boarding-school might become a dietetic sanitarium. The following list of hygenic *menus* is arranged in the order of their digestibility and wholesomeness:

Milk, bread, and fruit.—Eggs (raw or whipped), bread and honey. —Boiled eggs, bread, and apples (ancient Rome).—Bread and butter, rice-pudding, with sugar and fresh milk.—Corn-bread or roasted chestnuts, butter, honey, and grapes (the usual diet of the long-lived Corsican mountaineers).—Fish, butter, oatmeal-porridge, and fresh milk (Danish Islands).—Pancakes, honey or new molasses, poached eggs,

* Pereira, "Treatise on Food and Diet," p. 242.

† Wodderstadt, "On Yellow Fever," p. 72.

boiled milk, and bread-pudding.—Vegetable soups, baked beans, potatoes (baked or mashed), butter, biscuits, and apple-dumplings.

General Rules.—Avoid stimulants ; alcoholic and narcotic drinks, tobacco, and all pungent spices ; be sparing in the use of animal food, especially in summer-time ; in midsummer eat fruit with every meal ; let unprepared food (fresh milk, fruits, etc.) form a part of your daily fare ; of unprepared aliments as well as of all unspiced viands, the most palatable are the most wholesome ; eat slowly and masticate your food ; never eat if you have no appetite ; and finish your last meal three hours before bedtime.

As a dessert I will add a few of my favorite dietetic aphorisms : An hour of exercise to every pound of food.—We are not nourished by what we eat, but by what we digest.—Every hour you steal from digestion will be reclaimed by indigestion.—Beware of the wrath of a patient stomach !—He who controls his appetite in regard to the quality of his food may safely indulge it in regard to quantity.—The oftener you eat, the oftener you will repent it.—Dyspepsia is a poor pedestrian ; walk at the rate of four miles an hour, and you will soon leave her behind.—The road to the rum-cellar leads through the coffee-house.—Abstinence from *all* stimulants, only, is easier than temperance.—There are worthier objects of charity than famine-stricken nations that send their breadstuffs to the distillery.—An egg is worth a pound of meat ; a milch-cow, seven stall-fed oxen.—Sleep is sweeter after a fast-day than after a feast-day.—For every meal you lose you gain a better.

How often should we eat is still a mooted question. For men in a state of nature the answer would be simple enough ; but, considering our present artificial modes of life, I must say that the choice of fixed hours is less important than the observation of the following rule : *Never eat till you have leisure to digest.* For digestion requires leisure ; we can not assimilate our food while the functional energy of our system is engrossed by other occupations. After a hearty feed, animals retire to a quiet hiding-place ; and the "after-dinner laziness," the plea of our system for rest, should admonish us to imitate their example. The idea that exercise after dinner promotes digestion is a mischievous fallacy ; Jules Virey settled that question by a cruel but conclusive experiment. He selected two curs of the same size, age and general *physique*, made them keep a fast-day and treated them the next morning to a square meal of potato-chips and cubes of fat mutton, but, as soon as one of them had eaten his fill, he made the other stop too, to make sure that they had both consumed the same quantity. Dog No. 1 was then confined in a comfortable kennel, while No. 2 had to run after the doctor's coach, not at a breathless rate of speed, but at a fair, brisk trot, for two hours and a half. As soon as they got home, the coach-dog and his comrade were slain and dissected : the kennel-dog had completely digested his meal, while the

chips and cubes in the coach-dog's stomach had not changed their form at all; the process of assimilation had not even begun! Railroad laborers, who bolt their dinner during a short interval of hard work, might as well pass their recess in a hammock; instead of strengthening them, their dinner will only oppress them, till it is digested, together with their supper, in the cool of the evening. In a manner essentially similar, mental activity tends to hinder the digestive process for a considerable time; and I believe, more especially, the digestion of the very substances that are often selected as brain-food *par excellence.* Even after a fashionable dinner of six or seven courses (*curses*, Dr. Abernethy used to call them), two hours of absolute rest will set our wits a-work again; but, if that time be passed behind a double-entry ledger, a feeling of lassitude, often combined with an almost resistless somnolence, will advise the brain-worker that his vital energy is needed for other purposes. "I could eat with more comfort if it wasn't for the consciousness of having to hurry back to my drudgery," I heard a poor class-teacher say, and the same consciousness embitters the noonday-meal of millions of school-children and overworked clerks.

Andrew Combe, M. D., informs us that a century ago the tradesmen of Edinburgh used to indulge in a "nooning," a general suspension of business for two hours, in the middle of the day. But an hour or so was thus probably spent in going home and back, dressing, etc., and half an hour at the meal itself; so that, after all, only thirty minutes remained for digestion; and, considering the anachronism of that nooning practice, the best plan, on the whole, would seem to be a general return to the method of the ancient Romans, who postponed their principal meal till their day's work was done. It would be an insult to common sense and humanity to doubt that the eight-hour system will ultimately prevail, and, where it has been already adopted, I can see no reason why mechanics could not arrange to finish their day's job at 4 P. M. Schools should always close at four. Bankers and government clerks often get home before that time, and competitive shopkeepers might carry on their business by relays. At half-past four, or, say, five o'clock, the *coena domestica* might begin, conclude before six; then *dolce far niente*, pleasant conversation, and four blessed hours for digestion.

But that principal meal should be the last. It is an important rule that we should digest our food thoroughly before we replenish the stomach. To counteract the effects of overeating, the gluttons of ancient Rome used emetics, the Parisian gastronomes stimulants. Dr. Alcott wants us to "leave off hungry"; the exponents of the movement-cure prescribe a certain system of gymnastic evolutions before and after dinner. But there is a better plan: *Lengthen the interval between meals.* Two meals a day are enough, perhaps more than enough, though we can accustom ourselves to swallow (not digest) five

or six. It all depends on training, and in no other respect is the human system so plastic to the influence of habit. The Rev. Mr. Moffat tells us that the Gonaque Hottentots are noways incommoded by a five days' fast, and get old on an average of four meals a week. The Greeks and Romans during the prime of their republics contented themselves with one meal a day; Claude Bernard recommends two, but his countrymen generally eat three; their German neighbors four; the East-Germans even five: breakfast, second breakfast (*zweites Frühstück*), dinner, *Vesperbrot*, and supper, to which supper the Vienna burghers actually superadd a *Nacht-bissel*—a "night-lunch," of cold potato-salad with bread and *Wurst*, and often with a mug of beer—"for the stomach's sake"! I get along comfortably with a meal and a half; so does my grand-uncle, an octogenarian, who still masticates his bread with a full set of unbought teeth. Two, or one and two halves, should be enough for any man. The lightest breakfast is the best—buckwheat-cakes with a little honey or apple-butter, and a glass of milk, or a cup of chocolate, if you must take "something warm." Chocolate possesses nutritive properties, which tea and coffee *per se* are totally devoid of. I never use it, but I believe it is non-stimulating. Or chew a crust of stale bread, the best dentifrice and a useful absorbent, good for acidity of the stomach. At noon take a glass of milk and a couple of biscuits, or in summer a couple of ripe pears or peaches; they will keep you cool during the post-meridian heat and do you more good than a cocktail lunch. Never keep a pocket-flask. Don't stay with flagons; better comfort with apples, if you can not wait till five. School-children should pass their recess on the playground. A biscuit and a pocketful of apples will satisfy the temporary demands of the stomach; and, if they have munched up their comestibles in the course of the morning, as boys are apt to do, they will find it far easier to forego their noonday lunch altogether than to resist the insidious somnolence which would dull their wits after a regular dinner, and often makes the afternoon lesson a protracted struggle between nature and duty.

But at the principal meal they should eat their fill. Let them pitch in, without fear of dangerous consequences—unless your landlord charges by the plateful. Children, like monkeys, have a way of dallying with their food if they are full—picking a crumb here and there, or mumbling their apples without using their teeth. Make them get up if you notice such symptoms, or, better, entice them away by improvising some out-door or up-stairs amusement. But I repeat, never press them to eat—for principle's sake—not even your young visitors; they are not likely to go to bed hungry if your *menu* comprises such items as baked apples or bread-pudding and sweet milk.

Jean Jacques Rousseau holds that intemperate habits are mostly acquired in early boyhood, when blind deference to social precedents is apt to overcome our natural antipathies, and that those who have

passed that period in safety have generally escaped the danger of temptation. The same holds good of other dietetic abuses. If a child's natural aversion to vice has never been willfully perverted, the time will come when his welfare may be intrusted to the safe-keeping of his protective instincts. You need not fear that he will swerve from the path of health when his simple habits, sanctioned by Nature and inclination, have acquired the additional strength of long practice. When the age of blind deference is passed, vice is generally too unattractive to be very dangerous. "Why make yourself the slave of such a degrading habit?" says Count Zinzendorf, in his "Hirtenbrief"; "it is so easy never to begin!" I go further. I say it is difficult to begin. Nature is not neutral on a point of such importance. Between virtue and vice she has erected a bulwark which she intended to last from birth to death. We need not strengthen that bulwark. We need not guard it with anxious care; it will stand the ordinary wear and tear of life. All we have to do is to save ourselves the extraordinary trouble of breaking it down.

Pure joys never pall; uniformity is uniform happiness if the even tenor of our way is the way of Nature. And Nature herself will guide our steps if the exigence of abnormal circumstances should require a deviation from the beaten path. Remedial instincts are not confined to the lower animals; man has his full share of them; the self-regulating power of the human system is as wonderful in the variety as in the simplicity of its resources. Have you ever observed the weather-wisdom of the black bindweed?—how its flowers open to the morning sun and close at the approach of the noontide glare; how its tendrils expand their spirals in a calm, but contract and cling, as with hands, to their support when the storm-wind sweeps the woods? With the same certainty our dietetic instincts respond to the varying demands of our daily life. Without the aid of art, without the assistance of our own experience, they even adapt themselves to the exigencies of our abnormal social conditions, and our interference alone often prevents them from counteracting the tendency of dire abuses.

Summer brings no repose to the slaves of Mammon, but dull headaches and the stomach's imperative demand for rest convince even the unwilling that intricate arithmetical problems and 90° Fahr. are incompatible with digestion; and I ascribe it to the logic of those gastric arguments that bankers and brokers now close their shops at 3 P. M.; and that business men generally avoid repletion in the middle of the day. "Cheese is gold in the morning, silver at noon, and lead at night," says a mediæval proverb; but the effects of those horrid cheese and porter breakfasts of Queen Anne's time satisfied our grandams that rotten curd and fermented (i. e., putrid) barley-broth are always lead, except to those who employ the hygienic philosopher's stone—active and long-continued out-door exercise. After recovery from an exhausting sickness—especially if you decide to promote that recovery by

throwing physic to the dogs—the demands of your stomach will often become exorbitant, but only apparently so; your system wants to repair the waste of the disease. Never fear that "the digestive organs are too feeble yet," etc.; those organs will keep their promise, unless you break yours by resuming medication. Have you eaten more than the wants of your system require? Your appetite will not respond to your invitation at the next meal. Take the hint—wait. Do not increase the troubles of your stomach by mordant spices and alcohol. In the sultry dog-days your system craves a surcease of greasy *ragoûts* and yearns for something refreshing—sherbet or cool fruit. Get a water-melon. "But isn't the yellow fever in town? Quack, Quinine, and other leading physicians, agree that one must take a course of antiseptics, and avoid vegetables at such seasons." Don't believe them; Nature knows better. Fruit is a better antiseptic than fusel poison and wormwood. The frugivorous Mexican survives where the beef-eating stranger dies in spite of his bitters. If sailors have been surfeited with salt meat, their craving after lemon-juice or fresh fruit becomes more urgent from day to day; the surcharge of their organism with saline matter requires a neutralizing acid. A single meal of salt herring excites merely thirst; common water is yet sufficient to dilute the ingesta and eliminate the salt. Vegetable substances that consist chiefly of starch and water supply the wants of our organism less completely than those that contain an admixture of gluten, albumen, and fat; and, if we restrict our diet to the first-named class of aliments, our system announces the deficit by means of our senses; without such complements as milk, sugar, or fat, rice-bread is more insipid than bread from unbolted wheat-flour.

All dietetic needs of our body thus announce themselves in a versatile language of their own, and he who has learned to interpret that language, nor willfully disregards its just appeals, may avoid all digestive disorders—not by fasting if he is hungry or forcing food upon his protesting stomach, not by convulsing his bowels with nauseous drugs, but by quietly following the guidance of his instincts.

Nature's health laws are simple. The road to health and happiness is not the labyrinthine maze described by our medical mystagogues. In perusing their dietetic codes one is fairly bewildered by a mass of incongruous precepts and prescriptions, laborious compromises between old and new theories, arbitrary rules, and illogical exceptions, anti-natural restrictions and anti-natural remedies. Their views of the constitution of man suggest the King of Aragon's remark about the cycles and epicycles of the Ptolemaic system: "It strikes me the Creator might have arranged this business in a simpler way."

All normal things are good, all evil is abnormal, is an axiom which has been almost reversed in the principle of our orthodox health theories, for many of our physical educators still hold to the cardinal error of their spiritual colleagues, who consider depravity and wretchedness

as the normal condition of man, and happiness as the reward of a self-abhorring suppression of all natural desires and of a blind confidence in the efficacy of an abnormal and mysterious remedy—nay, who despise Earth herself as a "vale of tears," and life as a disease whose only cure is death, whose only anodyne a dream of a supernatural elysium. It is time to awake from that dream. It is time to open our eyes to the well-springs of life and happiness which the bounty of our Mother Earth sends forth in such abundance, and which man might enjoy with all his fellow-creatures if his perversity had not turned them into sources of misery and death. Instead of insulting our Maker by the doctrine of innate depravity, we should learn to distinguish the voice of our natural instincts from the cravings of a morbid appetency. We should try to restore life to its original purity and healthfulness instead of despising it and looking for happiness beyond the grave.

But the deluge of mediæval superstitions is fast assuaging, and many a submerged truth has reappeared like a bequest of a former and better world, and now stands as a way-mark on the road to a true Science of Life. We have rediscovered the truth that the weal and woe of earth are not distributed by the caprices of a mysterious Fate, but that they follow as sure effects upon ascertainable causes. Our best thinkers have ceased to doubt that man can work out his own destiny, that the Creator has made us the keepers of our own happiness on conditions which he never violates; that he has attached pleasure to every right act, and pain to every wrong, that he fulfills the promises of our yearnings, and never permits us to sin unwarned. We have at last begun to realize the fact that the physical laws of God find an echo in the voice of our innate monitor, and only an hereditary mistrust in our instincts makes us still hesitate to commit ourselves to its guidance. But experience will overcome that prejudice by and by; duty and inclination will go hand in hand, and the result will justify our trust in the wisdom and benevolence of Nature.

HORSES AND THEIR FEET.

By Sir GEORGE W. COX.

If we say that of all brute animals none is more valuable to man than the horse, and that the neglect of any means which may promote and insure his welfare and efficiency is a blunder not easily distinguishable from crime, we may fairly be charged with uttering truisms. If we urge that this value is not recognized as it should be, and that this neglect is miserably common, we may still be accused of wasting breath on statements which no one would think of calling into

question. Every one, we may be told, is well aware that the management of horses is very faulty, that their lives are shortened by the ignorance of those who have charge of them rather than by any wanton cruelty, and that they are rendered practically useless long before their existence is brought to an end. To the plea that the same, or much the same, things may be said of men as of horses, we may answer that the blame must be apportioned to the degree of carelessness with which evils affecting either men or horses are allowed to go on unchecked, or are foolishly dealt with ; nor can failures to improve the condition of mankind furnish a reason for refusing to do what may improve the condition of horses. Our duty ought to be discharged at all costs and under all circumstances ; but a man must have risen far above the average of his fellows if he feels no relief when his duty coincides with his interest. Something is gained by the mere pointing out of this agreement, wherever it exists ; and we must remember that, if a vast amount of human wretchedness is the direct result of willful and wanton perversity, we can meet with no such resistance on the part of brute beasts. With regard to these we have only to see what the evils are ; and the blame is ours, and ours alone, if we fail to apply the remedy, when the remedy, if applied, must be successful. In the case of the horse, unhappily, we do not realize the extent of the mischief, and seldom, perhaps never, fix our minds on its cause or causes. Yet the facts, even when reduced within limits which none will venture to dispute, are sufficiently startling.

The number of horses in the United Kingdom has been estimated at rather more than two millions and a quarter, and their average value can scarcely be set down at less than thirty pounds. Their collective value, therefore, falls little short of £68,000,000. That the nation incurs a loss if this sum is spent quicker than it needs to be is a self-evident proposition ; that it is so spent is certain, if horses on an average become useless at a time when they ought still to be in full vigor. On this point few will be disposed to challenge the verdict of Mr. W. Douglas, late veterinary surgeon in the Tenth Hussars, who tells us that a horse should live from thirty-five to forty years, and live actively and usefully during three fourths of this period. "All authorities,' he says, "now admit that animals should live five times as long as it takes them to reach maturity. A dog, which is at its full growth when between two and three years old, is very aged at twelve years. Horses do not, unless their growth is forced, reach their full prime until they are seven or eight years old, which by the same law leaves them to live some thirty years longer. When these facts are kept in mind, together with these other facts that three fourths of our horses die or are destroyed under twelve years old, that horses are termed aged at six [he should have said eight], old at ten, very old when double that number of years, and that few of them but are laid up from work a dozen times a year, . . . the viciousness of a system

which entails such misery and destruction of life can not be too strongly commented upon." If we take the age of three years as that at which horses begin to work, and twelve as that at which they are worn out, it follows that the period of their efficiency is shorter by at least fourteen years than it should be. In other words, the nation has to buy three horses when it ought to buy only one, and thus upward of £200,000,000 are spent every twenty-one years in the purchase of horses when £68,000,000 ought to suffice. The loss, therefore, to the nation is at least £135,000,000 in twenty-one years.

If this were all, the question would surely be most serious; but it is not all. Unless the facts thus far stated can be set aside, our horses work on the average seven or eight years; but how do they work? The collective experience of the country will answer that the work is done at the cost of frequent interruptions, and with an amount of discomfort and pain which often becomes agony. It is easy to say that much of the evil must be laid to the charge of grooms and stable-men; and perhaps the censures dealt out to these men are not undeserved. They are, at least, outspoken. In the last century Lord Pembroke spoke of grooms as being "generally the worst informed of all persons living." "No other servant," says Mr. Mayhew, "possesses such power, and no domestic more abuses his position. It is impossible to amend the regulation of any modern stable without removing some of this calling, or overthrowing some of the abuses with a perpetuation of which the stable servant is directly involved." In this state of things the most humane of masters becomes, he adds, an unconscious tyrant to the brute which serves him so well. It is a miserable fact that grooms on their own responsibility are in the habit of administering secretly to horses medicines the cost of which they pay themselves. It may fairly be said that in every case the remedy is ill-judged, and creates worse mischief than that which it is designed to remove. Among these medicines, arsenic, antimony, and niter seem to be the favorites; but the list of remedies is not ended with these. The experience of ages, if it has failed to do more, has impressed on them the fact that the chief source of the sufferings of horses is to be found in the foot. The suspicion that the foot is not treated rightly by the traditionary method never enters their minds; and they deal with the limb not from a knowledge of its anatomy, structure, and purpose, but in accordance with the popular notions, which are, in plain speech, outrageously absurd. In profound ignorance that the hoof is porous, they apply hoof-ointments, which answer to cement plastered on a wall. If these were in constant use, Mr. Douglas asserts emphatically that not a morsel of sound horn would remain at the end of six months on the horses, and shoeing would become an impossibility. If the groom be told that he is thus preventing the internal moisture from reaching the outer surface and the air from circulating inward, his only answer is an incredulous laugh. His conviction is that the hoof should not come

into contact with hard material, and that the horse can be best fitted for his work by having his feet smeared with tar, beeswax, or tallow, and by resting always on a heap of litter in the stable. It would be of little use to cite Lord Pembroke as declaring that "the constant use of litter makes the feet tender and causes swelled legs; moreover, it renders the animals delicate. Swelled legs may be frequently reduced to their proper natural size by taking away the litter only, which, in some stables, where ignorant grooms and farriers govern, would be a great saving of bleeding and physic, besides straw. . . . I have seen," he adds, "by repeated experiments, legs swell and unswell by leaving litter or taking it away, like mercury in a weather-glass"; and his experience is confirmed by the general condition of troopers' horses, in contrast with those of their officers, which are bedded down all day.

But, if there are evils for which grooms are in large measure directly responsible and the abolition of which they would beyond doubt stoutly resist, there are others in which masters are not less blameworthy than their men, and from which the public generally as well as the animals are constant sufferers. The work of the horse is that of dragging and carrying; and the aim of the owner should be the accomplishment of this work with the utmost possible sureness and with the fewest accidents. Serious and fatal injuries may be the result of stumblings and slippings not less than of actual falls; and the premature wearing out of horses by excessive straining of their sinews and muscles is a direct pecuniary loss to the owners, although few of them seem to realize the true significance of the fact. These evils are to be seen everywhere, and they affect horses kept for the purpose of pleasure and ostentation almost as much as those which spend their days in a round of monotonous drudgery. A horse should not be obliged to work in going down a hill; but, in fact, they are subject to the severest strain just when they ought to have none, if they are harnessed to springless carts or wagons without breaks. Farm-horses suffer with terrible severity from this cause; but the horses used in carrying trades and by railway companies undergo a more cruel ordeal. Improvements in the break-power of wagons used on roads, which might greatly lessen the mischief, are not made, and hence the horses are seldom free from diseases more or less serious, which may be traced directly to constant slipping and shaking over slippery pavements. Among ignorant owners, blind to their own interests, there is an impression that "the work which kills one horse will bring in money enough to buy another"; but experience has sufficiently shown the fallacy of this theory, whether the overtaxed slave be a horse or a human being. In towns and cities the roads are, and must be, paved, and the pavings at present are variously of stone, wood, or asphalt, where the road is not macadamized. These pavements have, it would seem, each its own peculiar dangers for the horses which use them; and each has thus become a fruitful source of controversy. If any

one method be likely to supersede the rest, the victory will probably be for the asphalt; but horses are found to slip seriously upon it, and the falls so caused are, we are told, of a graver kind than those on pavements of other sorts. All the proprietors of cabs, omnibuses, and railway-vans have, it is said, protested in a body against its use, but scarcely, it would seem, to good purpose. Fresh contracts have been signed for pavements of asphalt, and others will probably follow. In the mean while horses have to pass, perhaps in a single morning, from macadamized roads to roads paved with asphalt, wood, or stone—in other words, over roads made of widely differing materials, which call in each case for a different action of the foot. On the other hand, the hoof is supposed to be protected by shoes, the varieties of which are legion; and thus the controversy has been brought to a singular issue. On one side it is urged that there should be a uniform system of paving enforced on all towns, so that horses should no longer pass from a less slippery road to one that is more slippery; on the other the contention is that the true remedy lies not in uniformity of paving, but in the discovery of a shoe which shall effectually prevent the horse from slipping anywhere. The former alternative is visionary; the latter has been, and perhaps it may be said still is, the object aimed at by some who have a thorough acquaintance with the structure of the horse, and the most disinterested wish to promote his welfare. We may therefore safely pay no heed to the lamentations of those who believe that "the difficulty in riding or driving through the London streets arises from the variety of the pavements in use," and that, "if we had a uniform kind of pavement, a shoe for universal use would be quickly invented." We may please ourselves with fancying that "the ingenuity of man would devise horseshoes to travel over glass, were glass the only pavement in use." The main question is, whether mankind after all has not been forestalled in this invention; and it is absolutely certain that those who have labored most conscientiously to improve the shoeing of horses have striven especially to secure for them the power of moving safely over materials of many kinds. These men have been convinced that the traditional methods overload the foot of the horse with iron, and that the modes of fastening on this iron interfere with, if not altogether obstruct, the processes of nature. The efforts of all have been directed toward diminishing the weight of iron, and this has led them to the conclusion that the less the natural foot is interfered with the better. M. la Fosse thus inferred that one half of the ordinary shoe was unnecessary, and that nothing more was needed than a tip on the front half of the foot. Unfortunately, he directed that the heel should be pared, thus making it weaker, and he fastened on his tip, which had about six inches of iron in its entire length, with eight nails. He was thus "inserting wedges, amounting in the aggregate to from one to one and a half inch in thickness, in six inches of horn, thus squeezing it into the space of five or even four

inches, and killing it from the clinches downward and outward." It is strange that veterinary surgeons who have clearly comprehended the mischief thus caused have failed to draw the logical inference from their premises. Mr. Douglas was aware that the crust of the horse's foot resembles in its natural state a number of small tubes, bound together by a hardened, glue-like substance, and he compares it to a mitrailleuse gun with its many barrels soldered together. By his way of nailing, M. la Fosse was reducing the size of each tube by one sixth, or rather was entirely closing those nearest the nails and compressing those that lie half-way between each pair of nails. He was in this respect aggravating the mischief of the ordinary shoe, which commonly has seven nails ; and this insured dryness and brittleness of hoof. But the circulation of fluid through the pores of the hoof is not the only natural process which modern shoeing interferes with. In his work on the horse's foot, Mr. Miles illustrates the expansion and contraction which always take place in its natural state when it is set down on and lifted from the ground. The subject was a horse nine years old, which had the shoe removed for the purpose of the experiment. "The unshod foot was lifted up, and its contour traced with the greatest precision on a piece of board covered with paper. A similar board was then laid on the ground ; the same foot was then placed upon it, and the opposite foot held up while it was again traced. The result was that it had expanded one eighth part of an inch at the heel and quarters." Over two inches on each side of the center of the toe no expansion had taken place, the tracings showing that the expansion was only lateral. It would follow that a shoe intended to give full play to this process must be confined to the part where no expansion takes place ; but Mr. Miles adhered to the form of the ordinary shoe, although he reduced to three the number of nails by which it was fastened. The object of this process of expansion and contraction is to give the animal a firmer hold on the soil, and to enable him, where this is thick, slimy, or sticky, to withdraw the foot easily on contraction. This purpose is necessarily defeated when the whole foot is armed with iron.

No one has condemned the mischievous working of the existing system more strongly than Mr. Mayhew, who refuses to allow that the body of the horse was made stronger than his legs and feet, and holds that these, if left to themselves, must be adequate to the tasks imposed on them. In his belief, "it is among the foremost physiological truths, that Nature is a strict economist," and that "man has for ages labored to disarrange parts thus admirably adjusted. . . . No injury, no wrong, no cruelty, can be conceived, which barbarity has not inflicted on the most generous of man's many willing slaves." But, although he has thus seen "the folly of contending against those organizations which govern the universe," he still thought that the employment of some sort of shoe might not lie open to this charge. Shoes of some

sort may give to the horse the freedom which is essential for the health of the foot, although he insists that all the shoes thus far used are lamentable failures. "There are," he says, "many more pieces of iron curved, hollowed, raised, and indented than I have cared to enumerate. All, however, have failed to restore health to the hoof. Some by enforcing a change of position may for a time appear to mitigate the evil; but none can in the long run cure the disorder under which the hoof evidently suffers." Such language, it might be thought, could come only from one who had discarded the use of shoes altogether. All, however, that Mr. Mayhew has done, is to point the way to the road which he was not prepared to take. But the experience of Miles and Mayhew, La Fosse, Charlier, and Douglas, seems to lead by necessary logical inference to one conclusion only. If the working of the traditionary system leaves the horse a wreck almost before he has reached his prime, if the lessening of the weight of iron and of the number of nails used in fixing the iron has been followed by direct and important benefits in every instance, if even those who hold that a horse must be shod have discovered that that which they look on as a protection to the fore-feet is merely harmful to the hind-feet, is it possible to stifle the suspicion that this insignificant remnant of a system so fruitful in mischief may have no magic power, and, in short, that the horse may do just as well without them?

This conclusion has been courageously avowed and most ably enforced by a writer calling himself "Free Lance," in his recently published work on "Horses and Roads"; and, to say the least, it is time that the whole question should be fully and impartially considered. It affects the wealth of the nation, and on it depend both the usefulness and the comfort of a race of noble animals which are indispensable to our prosperity. The force of prejudice may be great, and a widespread traditional system may not be soon or easily overthrown; but it can not for a moment be supposed that Englishmen generally will assume with reference to it an attitude of unreasoning and obstinate antagonism. Fear probably will be found to supply a restraining motive more powerful than open ill will. Many who think that the new theory may look well enough on paper will doubt its value in practice, and will regard their own horses as exceptions to which it can not apply. With a strange ignorance of fact, they will insist that unshod horses may move safely over smooth and soft ground, but must fail when it is rugged, and hard, and stony, or will be oppressed by a vague dread that a horse which has gone well enough without shoes for six months may break down in the seventh. But even those who refuse to give up the practice of shoeing will yet acknowledge its faultiness, and wish that they could give it up without risk. To all such we need only say that if they have any regard for impartiality they are bound to consider the arguments and the facts on which the conclusions of "Free Lance" rest; and most assuredly they will find in

his pages nothing which they may charge with extravagance, rashness, and intolerance. They will not be told that unless they abandon the system of shoeing altogether they can effect no improvement in the present state of things, or even that they must hasten to change the old system for the new. On the contrary, they will find that they are again and again warned against imprudent haste, and are told that a vast amount of good may be achieved even if they never venture on leaving their horses' feet in a state of nature.

Of these arguments and facts it might be difficult to determine which are the most important and significant. Certain it is that our horses generally are afflicted with a multitude of diseases which seize on their legs and feet, and that lameness is everywhere a cause of constant complaint and of loss of time and money. The author is not speaking from theory or from book, but takes his stand on an experience obtained during a sojourn of many years in foreign countries, especially in America, where in the construction of railways and other public works he had to employ hundreds of horses and mules on tasks which taxed their capabilities to the utmost. In Mexico, Peru, Brazil, and elsewhere, he found that unshod horses were daily worked over roads of all kinds, carrying heavy packs from the interior down to the coast, the journey thither and back being often extended to several hundreds of miles, and that they accomplish these journeys without ever wearing out their hoofs; and the roads in these countries, where they exist at all, are neither softer nor smoother than those of England or of Ireland. If horses fell lame, it was from causes incidental to the climate, and for these the system of shoeing would supply no remedy. From other diseases, which from strong and often incontestable reasons may be traced to the use of shoes, they were wholly free. The necessary conclusion was that the system of shoeing could answer no good purpose, while it might be productive of much harm; and in this conclusion he was confirmed by the admissions and protests of the most able and competent veterinary surgeons in this country. These have uniformly raised their voices against the heavy weighting of the horse's foot maintained by the traditional practice. It has been found here that the hoofs of some horses are so weak that they can not be fully shod; and a writer in the "Field," styling himself "Impecuniosus," cited some ten years ago a remark by Mayhew that "some horses will go sound in tips that can not endure any further protection," adding the significant comment that the moral of this is that "it is the shoe, not the road, that hurts the horse"; for, if a weak and tender foot can go sound when all but unshod, "why should not the strong, sound one do the same?" The conclusion, as he insists, should rather be that a horse must have a strong, sound foot to stand, not our work, but our shoe. The same writer, speaking of the cruelties unwittingly perpetrated by grooms and blacksmiths on the horse's foot, says that, "though lameness usually attends their efforts, they ascribe it to every

cause but the right one, and, indeed, resign themselves complacently to the presence of many diseases confessedly caused by their treatment." "Free Lance" has seen, and others also have doubtless seen, light horses, of high breed and value, shod or burdened with a full set of shoes in which eight nails, nearly three sixteenths of an inch in thickness, were driven four in each quarter, and in a space of three inches for each four nails. He may well call attention to the immense amount of laceration and compression which the delicate hollow fibers of the crust must have suffered when thus wedged up within a fourth of their natural dimensions. Besides this, he adds, the hoof was, in one instance, carved out on the crust to receive three clips, one on the toe and one on each quarter. "A calk, three quarters of an inch high, was put on one heel of each hind-shoe, and, on the other heel, a screw cog of equal height. On each front-shoe a cog, also three quarters of an inch high, was put upon each heel. This wretched victim to fashion was then regarded with the utmost satisfaction by the farriers and his groom; and all this heathenism was perpetrated in the forge of a veterinary surgeon. But, perhaps, he was shoeing to order."

Among the reformers of these great abuses M. Charlier occupies a prominent place. His shoe in its first shape was not successful. Starting rightly on the assumption that Nature intended the horse to walk barefoot, and that the bottom of his foot was in every way fitted to stand all wear and tear, he excepted from these self-sufficing parts the outer rim, that is, the wall or crust. "He, therefore," "Free Lance" tells us, "made a shoe of very narrow iron, less than the width of the wall, which he let in, or imbedded, to the crust, without touching the sole even on the edge; so that, in fact, the horse stood no higher after he was shod than he stood when barefooted. He urged that such a narrow piece of iron would not interfere with the natural expansion and contraction of the foot; and in this he at once went wrong, for malleable iron has no spring in it. Then, in spite of his theory, as he expressed it, he carried his shoe right round the foot into the bars, beyond where the crust ceases to be independent of them. He then got a very narrow, weak shoe, about a foot in circumference (if circumference can be applied to that which is not a complete circle); and, as he ought to have foreseen, the shoe then twisted or broke on violent exertion." Still, as freeing the horse from a large amount of the weight usually attached to his foot, the change was an important benefit; and the lesson thus taught was not thrown away. The shoe was reduced by a man at Melton from the full to the three-quarter size, and in this form it weighs five ounces. Seeley's patent horseshoe, adopted by the North Metropolitan Tramways Company, weighs one pound and a quarter, this being a reduction of one half on the weight of the ordinary shoe; and we have to remember that each additional ounce on the horse's foot makes a most sensible difference in the amount of work performed by him during the day. Shoeing their

horses on the principle of the modified Charlier shoe, Messrs. Smither & Son, of Upper East Smithfield, have found the result marvelously to their advantage, in the measure of comfort and safety with which their animals do their work, whether in the London streets, on pavement, or on country roads. So far as their experience has gone, there are no horses which it does not suit, and it is of special service for young horses running on the London stones, and for horses with tender feet, or corns, and to prevent slipping. In other words, the absence of metal confers benefits which can not be bestowed by its presence. Facts in America teach the same lesson. At a meeting of the Massachusetts Board of Agriculture in 1878, Mr. Bowditch, a practical farmer, declared that "nine hundred and ninety-nine thousandths of all the trouble in horses' feet come from shoeing," that he was in the habit of driving very hard down hill, that he had galloped on ice on a horse whose feet had merely a small bit of iron four inches long curled round the toe, and that this piece of iron is all that is needed even in the case of an animal whose feet have been abused for a series of years. When nothing is left but this fragment of the traditional shoe, and when even this fragment has, as in Massachusetts and elsewhere, been retained for the fore-feet only, it is incredible that men should fail to ask what the use of this relic of the old system may be. Donkeys in Ireland are unshod, and they work on roads at least as rough, hard, slimy, and slippery as those of England. "Can one really believe," asks "Free Lance," "that the animal which is endowed with the greater speed and power should have worse feet than his inferior in both respects?" To such a question one answer only can be given ; and the lesson may be learned by any one who will take the trouble to go to the wilds of Exmoor or Dartmoor. There, as in the Orkneys and on the Welsh hills and in many parts of the Continent of Europe, horses run unshod over rocks, through ravines, and up or down precipitous ridges. "Yet all this," Mr. Douglas remarks, "is done without difficulty, and to the evident advantage of their hoofs, for these animals never suffer from contracted feet, or from corns, sand-cracks, etc., until they become civilized and have been shod." Mr. Douglas, it is true, holds that civilization involves the need of a shoe of some sort for horses as for men; Mr. Mayhew advocates the use of the tip, and, as we have said, it is not in human nature to stop short at such a point as this. It is obvious that, if the complete abandonment of iron is followed by increased efficiency and power of endurance on the part of the horse, as well as by deliverance from a number of painful and highly injurious diseases, the owner is directly and largely benefited in more ways than one. His horses live in greater comfort and for a longer time ; his veterinary surgeon's bill and the outlay for medicine are greatly lessened, and the costs of farriery disappear altogether.

Farriers will, of course, complain that their occupation is gone,

and that they are ruined men ; but little heed was paid to like pleas when they were urged for the drivers and attendants of coaches and coach-horses when the first railways were constructed. Matters will adjust themselves in this case as they did in the other. But, that the change can not be effected in a day or a week, no one will venture to deny. The feet of horses are ordinarily treated, not wantonly but through ignorance, with a cruelty which is simply shocking. With vast numbers of animals which are not kept for purposes of drudgery, and in whose appearance their owners feel a pride, the hoof is a mere wreck, and the sight of the mangled and split hoof may well excite not merely pity but wonder that any can passively allow such evils to go on. A few, however, will always be found with resolution enough to shake off the fetters of traditionalism ; and some of these have already expressed their opinion with sufficient emphasis. One of these, writing in November, 1878, says: "The argument against horseshoes seemed to me so strong, and the convenience of doing without them so great, that I resolved to try the experiment. Accordingly, when my pony's shoes were worn out, I had them removed, and gave him a month's rest at grass, with an occasional drive of a mile or two on the high-road while his hoofs were hardening. The result at first seemed doubtful. The hoof was a thin shell, and kept chipping away, until it had worn down below the holes of the nails by which the shoes had been fastened. After this the hoof grew thick and hard, *quite unlike what it had been before.* I now put the pony to full work, and he stands it well. He is more sure-footed, his tread is almost noiseless, and his hoofs know no danger from the rough hands of the farrier, and the change altogether has been a clear gain, without anything to set off against it. The pony was between four and five years old, and had been regularly shod up to the present year. He now goes better without shoes than he ever did with them."

A well-known Cumberland farmer, writing about the same time, speaks of a farm-horse in his possession, which, having been lamed by a nail driven into its foot, had been for many months in the hands of the farrier. Tired out with this annoyance, the owner had his shoes taken off and turned him out to pasture. While still rather lame, the horse was set to work on the land; and he is now, we are told, "doing all sorts of farm-work, and dragging his load as well as any shod horse, even over hard pavement." If judgment based on knowledge is to carry weight, the question would soon be settled. We have already seen the opinions expressed by the most able writers on the horse, and especially on the structure and treatment of his feet, as well as by the best veterinary surgeons. The verdict of the "Lancet" is almost more emphatic. "As a matter of physiological fitness," it says, "nothing more indefensible than the use of shoes can be imagined. Not only is the mode of attaching them by nails injurious to

the hoof, it is the probable, if not evident, cause of many affections of the foot and leg, which impair the usefulness and must affect the comfort of the animal." If we add that the hunter is benefited almost more than other horses by being allowed to use his feet as Nature made them, the admission is made in the interests of the horse and not as an expression of opinion on the controversy respecting the right or the wrong of fox-hunting. It is enough to say that for horses which have to move rapidly, and to come down with a sudden shock on sticky and slippery ground, the natural course of the process of expansion and contraction is of the first importance. For those who may care nothing for the gratification of hunting-men, it may be amusing or provoking to learn that, in times of hard frost, hunters have been enabled to chase the prey by the aid of gutta-percha soles fastened to the feet; but all who are anxious only for the welfare of the horse will see in this fact strong evidence of the uselessness of the iron shoe. The plain truth is, that differences in the quality of soil, be it hard or soft, stony or sandy, smooth and slippery, are of comparatively little importance to the horse whose feet are as Nature made them. In the words of "Free Lance," "the unshod horse can successfully deal with all roads"; and assuredly no one will dream of asserting that shod horses can do this, for on the setting in of frost, for instance, they can not be worked until certain ceremonies have been gone through at the blacksmith's forge. The unshod horse can tread firmly on the slime of wood pavement when shod horses are slipping and struggling in agony around them; he can gallop on ice, and trot for miles together on the hardest and roughest flint roads, with far more ease and comfort than horses whose feet are shod with iron, or even with gutta-percha. "Free Lance" rightly remarks that "if they could not there would be an end of the thing, for evidently the horse should be able to go anywhere and everywhere, and at a moment's notice." It seems hard to produce the conviction that the natural sole of the horse's foot is almost impenetrable, that it is so hard and strong as to protect the sensible sole from all harm, and that all feet exposed to hard objects are made harder by the contact, provided only that the sole is never pared. This adequacy of the horse's foot to all demands that may be made upon it is forcibly illustrated by Mr. Bracy Clark, who, like Mr. Douglas and Mr. Mayhew, contented himself with striving to produce a perfect shoe, although he acknowledged that, if we wish to appreciate the full beauty of its structure, "we must dismiss from our views the miserable, coerced, shod foot entirely, and consider the animal in a pure state of nature using his foot without any defense. Probably Mr. Clark thought that, though we may consider it in its natural state, few can ever so behold it, as all horses in civilized countries are in greater or less degree brought under artificial conditions. The plea is fallacious. The horse is clearly intended by nature to serve as a domesticated animal; and, so long as we do not interfere with the

proper functions of any part of its body (and the abomination of bearing-reins and other such practices interfere with them grievously and even fatally), we bring it under no conditions which it was not designedly calculated to encounter. Private owners and companies whose horses must be numbered by troops are naturally irritated by the accidents constantly occurring on smooth and slimy pavements or on rough and hard stone or flint roads, and in their disgust they now offer rewards for the invention of a shoe which shall render the horse indifferent to the materials over which he has to pass, and clamor for a uniform system of pavements in all towns. It seems strange indeed that no misgiving seems to cross their minds that they are taking thought of the wrong surface, and that they are scared by false terrors when they dread the contact of the unshod hoof with sand, granite, flint, wood, or asphalt.

It can not, indeed, be too often repeated or too strongly insisted on, that the foot of the horse in no way needs to rest on soft and yielding surfaces. The very opposite of this is the truth, and this truth was perceived as clearly by Xenophon as by the ablest physiologists of our own day. Speaking, as he says, not from theory, but from wide and varied experience, Xenophon insists that, in order to insure the healthiness of horses, stable-floors must not be smooth or damp, that they should be lined with stones of irregular shapes, of much the same size as the animal's hoof, and that the ground outside the stable, on which it is groomed, should be covered in parts with loose stones laid down in large quantities, but surrounded by an iron rim to prevent their being scattered. Standing on these, the horse, Xenophon adds, will be in much the same condition as if he were traveling on a stony road, and, as he must move his hoof when he is being rubbed down as much as when he is walking, the stones thus spread about will strengthen the frogs of his feet. It is not easy to repress a certain feeling of shame at the disingenuousness of modern writers who have tried to shirk the difficulty by saying that Xenophon had no knowledge of our hard roads. It is enough to reply that he speaks distinctly of roads covered with stones, and of the benefit which the horse derives from traversing them. There is not a word to justify a suspicion that he would have shrunk from the hardest roadway of modern times. Xenophon is thus in complete agreement with Lord Pembroke's remark, that the constant use of litter in a stable makes the feet tender and causes swelled legs. In his judgment the bare stone pavement will cool, harden, and improve a horse's feet merely by his standing on it. Acting on the same principle, Vegetius, as "Free Lance" remarks, holds that the floor of the stable should be made, not of soft wood, but of solid hard oak, which will make the foot of the horse as hard as a rock. It should surely be unnecessary to say that these writers make not the remotest reference or allusion to the shoeing of horses. It was impossible that they could notice a practice which was unknown

to the ancient world, and which is in truth simply a modern, as it is also a most uncalled-for, barbarism. No iron helped to produce the heavy sound of solid horn which Virgil ascribes to the fiery steed of Pollux. Of late years we have heard much of the unjustifiable waste of time spent on classical literature which has no practical bearing on the interests of modern life. It is unfortunate that Xenophon's treatise on the management of horses has not formed one of the subjects for the upper forms of our public schools ; and it would be well if they were made to read with care a book written by one who wrote unfettered by the restraints of any traditional system, and who successfully brought the cavalry, as well as the infantry, of the Cyreian army of Greeks from the plains of Babylon to the shores of the Euxine. There they would see how thoroughly the rules laid down by the leader of the Ten Thousand for the selection and management of horses are in accordance with the highest scientific knowledge of the present day, and how happy an ignorance he displays of the long and dismal catalogue of diseases and miseries which a wrong-headed and ridiculous system has called into existence. No horses could be subjected to a more severe strain in every limb of their body than were those which Xenophon led from Cunaxa over the Armenian highlands to the walls of Trebizond ; yet we hear nothing of any special difficulties arising from diseases of the foot or leg. It may probably be said with truth that the strain endured by those horses could be borne only by unshod animals. Paul Louis Courier, the French translator of Xenophon's treatise, was so struck by the apparent soundness of his method, that he put it to the test by riding unshod horses in the Calabrian campaign of 1807, and he did so with complete success. But that which with him was a voluntary experiment has been for others an involuntary necessity. This was the case with many of our cavalry-horses during the Indian Mutiny, and their riders have declared that they were never better mounted in their lives. In the retreat of the French from Moscow, the horses, "Free Lance" remarks, lost all their shoes before they reached the Vistula ; yet they found their way to France over hard, rough, and frozen ground. In his invasion of America, Cortes could not carry about with him the anvils, forges, and iron needed for shoeing even the small number of horses which he had with him. But these horses did their work and survived it, and from them comes the fierce mustang of Mexico, which still goes unshod. There is great force in the remark of "Free Lance," that horses are not indigenous to America, this being their first introduction, and that the climate and locality, therefore, have not that influence over the hoof which they are commonly supposed to have. The small horses of the irregular cavalry at the Cape, which took part in the battle of Ulundi, had no shoes on their hind-feet, and few were shod even in front, but they held out longer and went miles farther than the shod animals ; and no complaints were made of any of them falling lame, although, as "Free Lance" adds,

"sheets of wet, slippery rock, and rolling stones in river-beds, would be calculated to try the hoofs to the utmost."

But it is scarcely necessary to cite more instances of the vast benefits which those who have had the courage to leave the feet of their horses as Nature made them have received under the most varied conditions of work, of soil, and of climate. Humanity and self-interest here point in the same direction, and only folly of the most perverse kind will have the hardihood to fight for the maintenance of the existing system. The cruelties practiced (whether unwittingly or wantonly) on the horse's foot have been extended over a series of generations, but the only penalty which remains to be paid for the ill doing of years is the surrender of a few days or a few weeks of the labor of the animal which has been thus misused. On the other side, there is a certainty that we shall be entering on a course which will triple the length of time over which the efficiency of the horse will be extended, and which, therefore, will, within twenty years, have saved the nation a hundred and thirty-five million sterling. It will further insure the immediate saving of all the money now spent on farriery, and this saving, which must be at the least forty shillings a year on every horse, will amount to two million and a quarter; and there will be the further saving in straw as well as on medicines, nostrums, and remedies no longer needed for animals rescued from a system which was a fruitful source of discomfort, disease, and death. The angry controversies which the subject is now constantly calling forth and exasperating will at the same time disappear. There will no longer be an outcry for uniformity in the system of paving towns, for horses will go as well on one kind of pavement as on another. There will no longer be querulous demands on inventors for the devising of a perfect shoe, because it will be clearly seen that this perfect shoe has been furnished already by nature, and that it is only human ignorance and conceit which has marred the work of God. We may now look back with some feeling of envious regret on the wiser, because more natural, methods of the ancient world; and future generations will look back with feelings of simple wonderment at the infatuation which could submit without a struggle to a system which doomed the horse to unnecessary disease and agony and to a premature death, while it deprived his owner of wealth often sorely needed for his own welfare and that of all depending on him. Of the ultimate issue there can be no doubt; but it is still the duty of "Free Lance," as of all whose eyes are opened to the mischiefs of the existing system, to fight the battle to the end.—*Fraser's Magazine.*

DOMESTIC MOTORS.

By CHARLES M. LUNGREN.

III.—GAS AND ELECTRIC ENGINES.

THE gas-engine differs from both the steam and hot-air engine in the character of the expansion of the elastic fluid employed and in the mode of applying the heat. In the one the fire is used to convert water placed in a vessel exterior to the engine into steam, which, let into the cylinder, moves the piston by its expansive force ; and in the other it is used to expand a volume of air contained in the cylinder or adjacent chamber.

In both, the heat is applied outside of the working cylinder, but the peculiarity of the gas-engine is that the heat is developed within the cylinder itself. A mixture of gas and air is by the operation of the engine drawn into the cylinder, and then exploded, the heat generated expanding the products of combustion, which, exerting a pressure against the piston, give it motion. Simple as is this mode of converting heat into work, the practical realization of it has been found to be exceedingly difficult, and it is only within a very few years that thoroughly serviceable machines have been constructed. The most economical result is obtained from expanding gases when the pressure they exert is a continuous and gradually diminishing one, such as that of steam in the steam-engine. With an explosive mixture, like that in the gas-engine, the expansion takes place with great rapidity, producing a sudden and unsustained pressure, from which it is difficult to get either an economical result or a steady operation of the mechanism. This rapidity of expansion can be decreased, and the pressure obtained approximated to that of the steam-engine, by altering the proportions of air and gas so as to produce a quick combustion instead of an explosion, and by introducing the gaseous mixture into the cylinder gradually, instead of all at once ; and it is in this direction that the improvements have taken place which make the latest forms of gas-engine so superior to their predecessors.

Among the first engines to obtain a moderate degree of success were those of Hugon (1858) and Lenoir (1860). Neither of these was, however, very economical in the use of gas, and, previous to the engine of Otto and Langen in 1867, none were produced that were at all satisfactory in this respect. This was, however, objectionable, owing to the intolerable din it made when in operation.

While this engine was at best but a very qualified success, it has led the way to a machine which is very far from being so. In the Otto silent gas-engine, introduced a few years since, and now made

in this country and Europe, and in both rapidly going into use, we have a machine that is a very satisfactory solution of the problems involved in the construction of this class of motors. In the matter of fuel it is nearly, if not quite, as economical as a steam-engine of corresponding power, and is, therefore, in actual use much more so, both

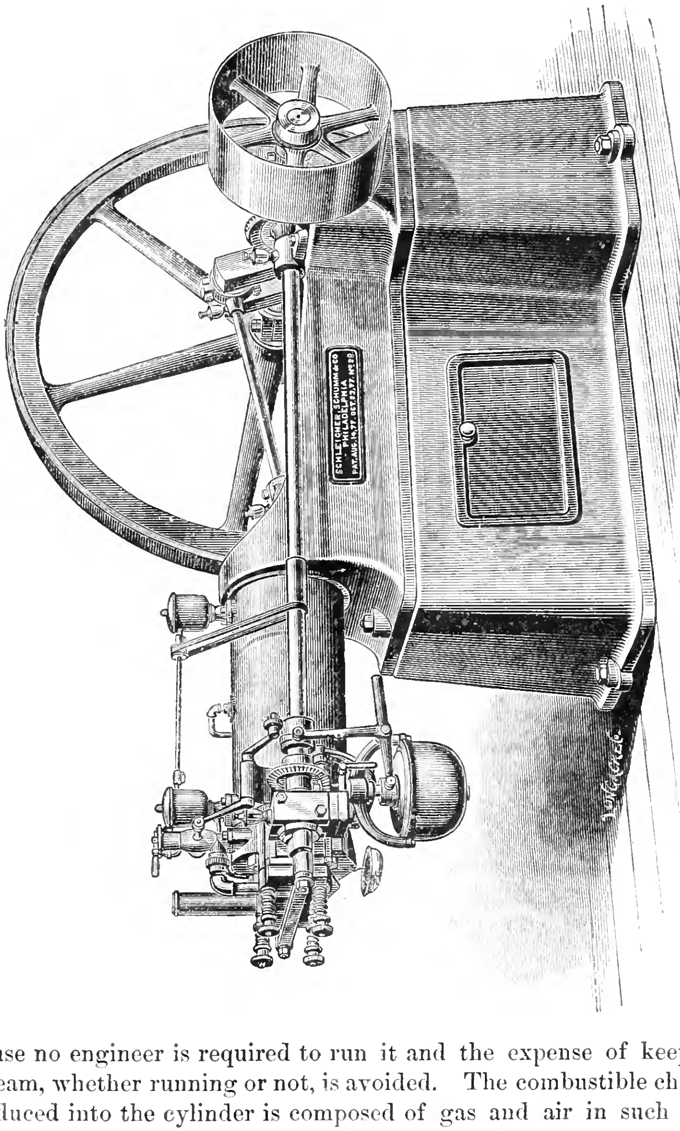
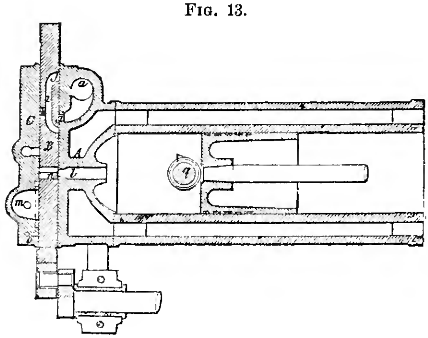


Fig. 12.

because no engineer is required to run it and the expense of keeping up steam, whether running or not, is avoided. The combustible charge introduced into the cylinder is composed of gas and air in such proportions that rapid combustion instead of an explosion takes place, and, to obtain sufficient pressure from its expansion, it is compressed to one third its original volume before being ignited.

In this country the engine is made for the trade in three sizes, from two to seven horse-power, but those of larger power are built when desired. The English makers furnish it from one up to forty horse, and as wide a range is given it on the Continent. The engine, as shown in the engraving (Fig. 12), is of the form constructed by the American makers. The cylinder is placed horizontal and overhangs the substantial bed-block of the machine. It is open to the atmosphere at the end toward the fly-wheel, and is closed at the other by a head-piece in which are the appliances for introducing and igniting the gaseous mixture, the construction of which is shown in the sectional cut Fig. 13. The head-plate A closes the cylinder entirely except at *l*, where there is a passage for the admission of the combustible charge. Between this plate and an outer one, C, is a slide-valve, B. The outer plate is pressed against the valve by the spiral springs shown in Fig. 12. The

FIG. 13.



pipe supplying the gas opens in its inner face at *c*, and at *m* there is a small jet constantly lit while the engine is in operation. The slide-valve B has two channels, *i* and *n*, the former placing the air and gas in communication with the cylinder, and the latter serving to ignite the mixture. The piston being at the beginning of its stroke, the valve B is in such a position that the air-inlet *a* and the gas-inlet *c* are in communication with the passage *l* through the port *i*. The piston then moves outward, drawing in a charge of air and gas which it compresses on its return, the valve B having moved so as to close the opening *l*. By this movement the channel *n* becomes filled with gas from the small supply-pipe *o*, which is ignited at the jet *m*. Just as the piston has completed the compression of the gaseous mixture, *n* arrives opposite *l* and ignites it, the valve continuing its motion so as to close the opening. The piston is driven outward by the expansion of the gases, and on its return they are expelled through the valve *q* in the side of the cylinder operated by the mechanism of the engine. The slide valve is reciprocated by a crank on the end of the lay-shaft, shown running lengthwise of the cylinder, which revolves but half as fast as the main shaft. The combustible mixture can therefore be drawn in only once

in two complete strokes, but whether a fresh supply is taken or not is determined by the governor, which acts to maintain a constant speed under varying loads. It is of the ordinary ball form, and is placed in the cup-shaped receptacle pendent from the cylinder. It actuates by its movement a lever controlling the gas-valve, so that this is opened and closed in accordance with changes in the speed. The regulation is delicate, and the speed nearly if not quite as uniform as in a steam-engine. The speed can be changed at will by increasing or diminishing the amounts of air and gas which may be drawn in each time. An automatic device is provided, which closes the gas-valve, should the engine by any accident stop in a position in which this would be left open. The oiling is committed almost entirely to the engine itself, the only work required in this connection being the filling of the oil-cups. They are placed upon the top of the cylinder, and by means of the small shaft and pulley driven from the lay-shaft deliver a given number of drops of oil to the slide-valve, cylinder, and piston at each revolution. The exhaust is rendered noiseless by being passed into a chamber, from which it escapes into the atmosphere under slight pressure. The cylinder is water-jacketed to keep it cool, the circulation of the water being maintained by the heat received, the warmer water rising to the supply-tank and the cool taking its place.

As before stated, the engine is very economical of gas. The amount used per hour per indicated horse-power is stated by the makers to be twenty-one and a half cubic feet, which, with gas at two dollars a thousand, is a trifle above four cents. In first cost the engine is somewhat more expensive than a good steam-engine, including boiler, of the same power, the price ranging from five hundred dollars for the two horse to eight hundred and fifty for that of seven horse-power. The former occupies a floor-space of about three feet by seven, and weighs fourteen hundred pounds, and the latter covers somewhat more space, and is of double the weight.

The heat generated by the combustion of the gas has been very fully utilized in this engine, but not to the greatest extent practicable. A certain portion of it is carried off by the water in the jacket, and is therefore wasted. If, instead of being allowed to escape without doing any useful work, it was employed to convert a small quantity of water injected into the cylinder into steam, overheating of the cylinder would be prevented, and at the same time this heat would be utilized. Besides the power gained, the use of steam is of value in giving a more sustained pressure on the piston and in lubricating the cylinder. Numerous attempts have been made to realize its advantages, both in hot-air and gas engines, but in most cases with no considerable gain in economy. The engine of Hugon, mentioned above, employed it, but apparently with little advantage.

Quite recently a gas-engine has been brought out in which the difficulties seem to have been mostly overcome, and which appears to ap-

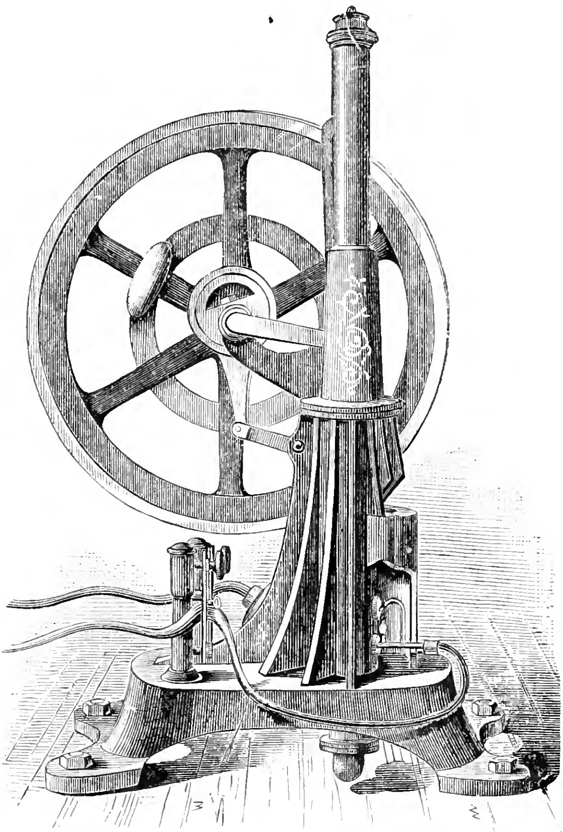
proach the limit of economy as closely as it is possible to do. It is the invention of M. Simon, and was first brought to extended public notice at the Paris Exposition of 1878, where it was exhibited in sizes of from one to four horse. A diluted mixture of air and gas is used, as in the Otto, but the compression is done not in the power but in a separate cylinder. It is admitted to the cylinder by a slide-valve of similar construction to that of the Otto, but the manner of using it differs materially from that employed in the latter machine. In the Otto the entire combustible charge is introduced into the cylinder before ignition takes place, and, though the proportion of air is such that the combustion is not an explosive one, still it is completed within a time that covers but a small fraction of the stroke. In the Simon, on the other hand, the combustible mixture is introduced in small quantities that are successively inflamed, producing a gradual expansion of the gases that, along with the steam also admitted, exert a pressure upon the piston more nearly like that in the steam-engine than is attained in any other machine. The ignition is accomplished by a jet always lit, placed just inside of several thicknesses of wire gauze, to prevent the flame retreating into the combustible mixture without the cylinder. The water that is afterward admitted to the cylinder is first used to jacket it, and thus becomes slightly warm. From the jacket it is passed into a steam generator, where a portion of it is vaporized by the heat of the exhaust-gases. This steam is then admitted into the cylinder along with the combustible charge, and further heated and expanded by the ignition of the latter. The water in the steam generator circulates through the jackets of both the compression and power cylinders, first taking heat from the compression cylinder, then from the power cylinder, and reaching the generator quite warm. The heat is therefore utilized to the utmost, and as a consequence the economical result is superior to any before attained. According to M. Simon, the consumption of gas is a little less than eighteen feet an hour per horse-power. The motor occupies a little larger floor-space than the Otto, though it is of less weight, and is somewhat higher in price.

Either of these engines could doubtless be made in sizes small enough to drive simply a sewing-machine or a scroll-saw, though probably not at prices that would allow of their extended use. Only one gas-engine appears to have been so far made of such small power—that invented by M. de Bisschof, and shown in Fig. 14. It is much simpler than the above engines, but is also a much less perfect machine, though sufficiently economical for the use for which it is designed. The ordinary machine is about one man-power, and is furnished at something over a hundred dollars; a larger one of four times the power costing a hundred and ninety. It is compact, ornamental in design, and runs smoothly. No oiling is required, and, once started, it may therefore be left to itself for a considerable time. One of them, indeed, is reported to have run for forty-seven days without

stopping, no attention whatever being given to it in that time. It is said to have gone quite largely into use in France, but it has not yet made its appearance in the American market.

In the engine as shown in the engraving, the cylinder is placed upright, and it and the base-plate are cast in one piece. A number of

Fig. 14.



ribs upon the former increase the radiating surface to such an extent that a water-jacket is unnecessary. The motor can therefore be readily moved from one place to another, an advantage of considerable value in the uses for which it is intended. The mixture of gas and air is admitted and discharged at the lower end of the cylinder through an opening, alternately placed in communication with the gas-supply and exhaust by a sliding valve. The firing of the gaseous charge is done by means of two gas-jets, shown on the right side of the engine. The lower one remains permanently lit, and serves to relight the upper one, which is extinguished at each ignition in the cylinder. This latter is placed directly opposite a small opening in the cylinder at about

one third of the piston-stroke from its base. The piston in its upward movement draws in a charge of the mixed gases during this lower third of its stroke, and they are then ignited by the jet, the remaining two thirds of the stroke being completed by the impulse due to their expansion. The atmospheric pressure and the fly-wheel carry the piston through its return-stroke, when the above motions are repeated. The supply of gas, both to the cylinder and the ignition-jets, is regulated by the pinch-cocks on the base of the machine, to the left. Before using, the machine is heated somewhat by a small burner placed below the cylinder. In the man-power machine the consumption of gas is eleven and a half feet an hour, which is a better result than is obtained with any other heat-engine of such low power. The motor seems to be in every way adapted to use in the household, and is probably as simple and perhaps as economical a heat-engine as can be made for the purpose.

The burning of a combustible mixture gradually, as is done in the Simon engine, was first successfully accomplished in the machine invented by Mr. George B. Brayton, and known in the market as the Ready Motor or Hydrocarbon engine. When first introduced, a dilute mixture of gas and air was employed, but in those now made the vapor of petroleum is substituted for the gas, with the advantage of a more satisfactory operation and a reduced cost of running. The working cylinder is surrounded by a water-jacket, and is placed upright in a substantial frame. It is open to the atmosphere below, the oil and air being supplied at the top. The oil is contained in a tank of from five to ten gallons' capacity, and is delivered to the engine by a small pump. Air is compressed by an air-pump in reservoirs, at the base of the machine, from which it is supplied to the cylinder. Only one of these reservoirs is used at a time, the other being kept charged so as to furnish an air-pressure with which to start the machine. The burner, by means of which the oil is introduced in the proper form into the cylinder and ignited, constitutes the main feature of the machine, and is at once simple and ingenious. It consists of a small chamber in the head of the cylinder, lined with a strip of felt against which the oil and a jet of air are delivered. The felt becomes saturated with oil, which the air-blast, passing through, carries in the form of a spray against the sheets of perforated metal and wire gauze which separate this chamber from the cylinder. Another and larger blast of air, in passing through the gauze, becomes carburetted by the petroleum vapor, and, entering the cylinder, is ignited by a jet placed immediately below the sheets of gauze. The jet remains constantly lit, and is prevented from retreating into the chamber above by the wire gauze. By simple mechanism the supply of air is cut off, when a part of the stroke has been made, and the combustion of the vapor ceases, the expanding products of combustion carrying the piston the remainder of the stroke. As the cut-off can be made at any point of the stroke, and

the expanding gases allowed to do the work of the remainder, the piston is subjected to a pressure entirely similar to and as readily controlled as that exerted by steam in the steam-engine. The piston is lubricated by its lower edge dipping into a shallow pan, F, at the bottom of the cylinder, containing oil, and the other parts in the ordinary manner. The motor is easily and quickly stopped and started, and when running requires but little attention. It is made in any size desired under ten horse, but those constructed for the trade are of three and five, the former being sold at four hundred and fifty dollars and the latter at six hundred. They are of about the same weight as the Otto, of corresponding power, and occupy a somewhat less space.

The engine is economical in the consumption of fuel, and with the present abundant supply of oil is the cheapest heat-engine of small power yet made. Five gallons of crude petroleum are used, it is stated, in the three, and seven and a half in the five-horse engine for ten hours' running. This is at the rate of one sixth of a gallon or one and a quarter pound an hour per horse-power in the smaller machine, and somewhat less in the larger. As the calorific effect of petroleum is almost double that of coal, the engine is nearly as efficient as a steam-engine of large size, and much more so than one of the same power, while, on account of the cheapness of petroleum, the expense for fuel is no greater. The oil used can be obtained in comparatively small quantities at from six to seven cents a gallon, and at the latter price the cost of a horse-power per hour would be a little less than one and a quarter cent, an expense considerably below the best results obtained in any of the engines using gas. This comparison is with the present cost of operating the latter motor, which is not one by which its possible economy is to be judged. The gas now used is the ordinary illuminating kind, and is high-priced. With a cheap fuel-gas, such as will assuredly come largely into use at no distant day, the cost would probably not be more than half that at present, and possibly less. This would bring it quite near that of the Brayton—near enough, at least, to make the advantage of the greater cleanliness and convenience of gas outweigh the gain in cheapness possessed by oil. An important objection to this engine is the one arising from the danger that accompanies the use of coal-oil. The motor itself is indeed quite safe, as much so as the gas-engine, and, if no more oil were stored than that in the tank from which the supply is drawn while working, the danger would be small. But when a considerable quantity is kept on hand in places where there is much valuable property, as in city buildings, the danger is sufficient to warrant increased insurance rates, and in some cases the prohibition of the machine. In situations where gas can not be procured, and where the use of oil would not be attended with the danger incident to crowded localities, it would probably be found one of the most satisfactory motors that can be had. Made in sufficiently small sizes of compact form, and with the oil receptacle and engine on one

base, it might easily become a serviceable motor for domestic use. As the quantity of oil used in such a machine would be small, it need not be in any way more dangerous than an ordinary lamp or oil-stove, and if properly finished would probably require but little more care. The oil used would of course have to be of a high grade, such as is used or should be used in lamps, and would cost considerably more than that suitable to the larger machines, but the expense of running would still be quite small.

Such are some of the best of the machines which the demand for comparatively small motors has, up to the present, called forth, and in the list those desiring such a power can scarcely fail to find something tolerably well suited to their wants. The various forms of heat-engines have been brought very close to the limit of possible simplicity, and show with some clearness what may be expected from further development along the same lines. They have been mainly designed to meet the requirements of industrial users, because the largest and most constant demand is from these ; but they are all capable of a reduction to the scale suitable in the household. For this purpose the gas-engine appears, on all accounts, to be the best adapted. Efficient and serviceable heat-engines are, of necessity, somewhat complicated, and require in their main parts an excellence and accuracy of workmanship that make it difficult to construct them cheaply. The gas-engine seems to be susceptible of greater simplicity of construction than any other of these, and can therefore be made at less cost. Present prices are undoubtedly high, but, with a sufficient demand and the competition that would result, they would decrease considerably, and it is not improbable that an efficient and economical machine of about one man-power could, under such conditions, be furnished at a price not exceeding fifty dollars.

But it is doubtful if such a machine would, after all, be the most satisfactory solution of the problem of a domestic motor. The final solution, there is reason to believe, is to be found, not in a heat-engine of any kind, but in a machine that will simply apply, in a convenient form and economical way, a power already furnished. Of such a nature is the water-wheel, which, for simplicity of construction, ease of handling, high efficiency, and small first cost, is unapproached by anything at present, and will probably never be surpassed by any future device. If water under sufficient pressure were everywhere obtainable, there would be no need of looking beyond this very simple and perfect contrivance. Water-power is, however, limited, and is generally least available where small motors are most wanted—in populous cities. Doubtless in many locations, where the windmill is employed to supply water to a house, a combination of wind and water power might readily be made which would prove quite satisfactory. A windmill of considerable power could be used to pump water into a properly elevated reservoir, or into a force-tank, from which it could be distributed to

small motors attached to the various pieces of apparatus to be driven. But generally, in cities where power could be distributed, people would prefer to have it furnished without thought or care on their part about its production.

For such a power, one that can at any time be increased to meet the utmost demands, we must, therefore, look to some other agency than water. Compressed air is, without question, an available one, and the motors in which it could be used are comparatively simple, but, as it could only be employed for this one purpose (unless, indeed, sanitary advantages were realized), the present or prospective demand would hardly warrant its adoption. The agent that appears to be the most suitable, and that gives promise of utility in other directions as well, is electricity. Distributed from a central source of supply, all the advantages of a safe and convenient power would be obtained, without any of the disadvantages attendant upon the use of other forms of energy. Of the feasibility of economically distributing the electric current there is a growing confidence among electricians, and the advantages of so transmitting power have been frequently urged of late, not only for moving light machinery, but for doing all the work now done in our factories by the steam-engine.

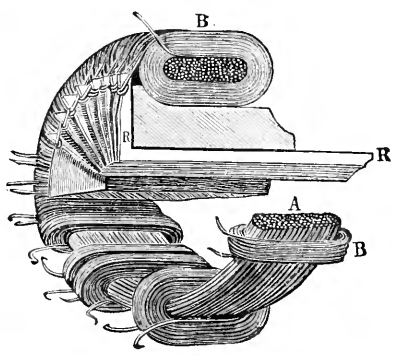
Distribution accomplished, the machines by which the current is utilized are very simple, and need not be expensive. As remarked by Dr. Paget Higgs, they are so much cast-iron and insulated copper wire, and their construction requires none of the skilled work necessary in the various forms of heat-engine. The construction is practically the same in the essential parts, whether they be used as current-generators or as motors. Briefly, such a machine consists of one or more electro-magnets placed so as to revolve before and very close to the poles of another electro- or permanent magnet, the former system of magnets being termed the armature, and the latter the field.

When permanent magnets are used for the field, the machines are known as magneto-electric, and, when these are replaced by electro-magnets, as dynamo-electric. The operation of both kinds depends, as is well known, upon the inductive action between the armature and the field magnets, a current being induced in each of the coils of the former as they approach, and an equal and opposite one being set up as they recede from the poles of the latter. In dynamo-machines the magnetization of the field is due to the currents generated by the machine itself. The soft-iron cores, after they have once been magnetized, always retain some residual magnetism which serves to induce a feeble current in the armature. A portion of this is sent through their coils, increasing their magnetization, which in turn augments the strength of the induced currents, and thus, by this successive action and reaction between the field and the armature, a very powerful magnetization of both is shortly produced. The currents are usually collected in such a manner that they both have the same direction in the circuit, by a sim-

ple device termed a commutator. This has various forms in different machines, but the principle involved is the same in all. The ends of the wire of the revolving coil are connected with the halves of a cylinder separated by an insulating substance. A metallic brush composed of bundles of wire, or thin strips, presses against each of these sections, and, so long as the cylinder remains stationary, the current taken off by the brushes will be an alternating one ; but, when the cylinder revolves with the coil, the brushes will change from one half to the other at the moment of the reversal of the current, and its direction in the circuit will, therefore, always be the same. In most machines the armature has many coils, and the commutator cylinder a corresponding number of insulated sections.

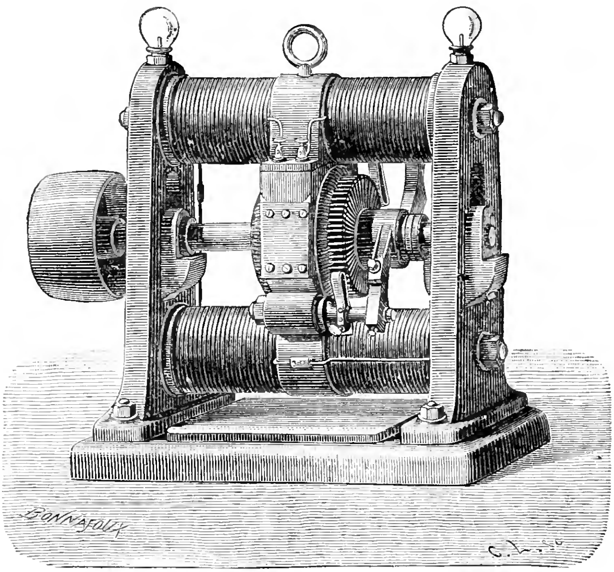
The interest in the electric light during the past few years has resulted in greatly improving such machines, and in the devising of many new forms of varied excellence. A description of one of these, that has attracted wide attention and proved one of the most efficient, will suffice to indicate the general construction and mode of action of such devices. When a magnet is inserted in a closed coil of insulated wire, a momentary current is induced in the coil, and, when it is withdrawn, one of opposite direction occurs. If, instead of withdrawing the magnet, it is passed through the coil, currents will be induced in each of its spirals as the magnet passes them, which will be in one direction during the passage of the first half of the magnet, and in a reverse one during that of the latter half. If two magnets be placed end to end with their like poles in contact, and be bent into the form of a ring, currents can be continuously produced by revolving the ring within an inclosing coil. Mechanical difficulties prevent such an arrangement ; but, if, instead of permanent magnets, a ring of soft iron be wound with insulated wire, and revolved between the poles of a magnet, the same results will be obtained and the difficulties avoided. The iron ring becomes a magnet by induction, and as it revolves its poles shift in the reverse direction, so as to always remain opposite those of the inducing magnet. The effect is the same as if the ring remained stationary and the coil revolved. This is the arrangement of the armature adopted in the Gramme machine, and the difference between it and others lies in this mode of inducing the current, instead of by insertion and withdrawal of a magnet from a coil. The manner in which the armature is actually constructed is shown in Fig. 15. The ring is composed of a bundle of soft-iron wires, about

Fig. 15.



which are wound a number of insulated coils. Radial pieces connected with the end of the wire of one coil and the beginning of the next conduct the currents to the commutator cylinder, when they are taken off by brushes. The armature is mounted upon a shaft and revolves between the poles of an electro-magnet, the arrangement being that shown in Fig. 16. When the machine is used on an electro-motor, the current enters the armature by the brushes and is alternately changed in direction by the commutator, so that there is attraction as the armature approaches and repulsion as it leaves the poles of the field magnet.

Fig. 16.



Besides machines constructed primarily to generate currents, but which may be used as electro-motors as well, there are various others designed especially for the latter purpose. The commonest form of these is a set of electro-magnets arranged radially around the armature, which is rotated under the influence of the changing polarity, or the magnetization and demagnetization of the field-magnets.

One of the best of the machines constructed for motor purposes, and one that has received high praise from competent electricians, is that of M. Marcel Deprez. It consists of a compound permanent horseshoe magnet with a Siemens armature between its poles. This latter is simply a soft-iron cylinder with two longitudinal grooves in which insulated copper wire is wound, the poles being the faces of the cylinder between the coils. It is placed with its axis parallel to the arms of the magnet instead of across them as is ordinarily done, and to this arrangement is due its greater power, as the whole strength of

the magnet is utilized. The current enters through the commutator, which reverses it at each half-revolution just as the poles of the armature are passing those of the field-magnet. The armature, therefore, rotates under these alternate attractions and repulsions. The rate of speed can be regulated with nicety by turning the brushes around the commutator cylinder to and from the neutral points. The speed is rendered uniform under a varying load by a very simple centrifugal governor, consisting of a small spring, one extremity of which is attached to an end of the armature coil, and the other rests against the commutator. When the speed increases beyond the normal rate, the free end of the spring is thrown out from contact with the commutator, and the current interrupted until this rate is regained. This governor has proved very sensitive in use, controlling the speed within variations of $\frac{1}{700}$ of its mean rate.

Excellent as this motor is, it has the defect common to all machines in which the armature is approaching or receding from the poles of the field-magnet during but a small part of each revolution. Currents are induced only during these periods, and hence much of the effective power of the field-magnet is lost. M. Trouvé has recently constructed a machine in which this defect is removed in a very simple manner. Instead of making the grooves in the Siemens armature parallel with its axis, they are cut in a spiral form, so that portions of the armature cores are approaching and receding from the poles of the field-magnet during the entire revolution. The impulse received by the armature is, therefore, a continuous one, and dead points are avoided.

The various electro-motors may of course be worked by currents furnished by ordinary batteries, and for running a sewing-machine a few hours a day, at a comparatively small cost. But, as a means of furnishing currents for power for any considerable time, such batteries are out of the question. As pointed out by Professor Ayrton, even if an electro-motor were a perfect machine—that is, if its efficiency were unity—it would be thirty-three times as expensive as a steam-engine, if operated by currents from such a source. The costliness of present batteries is, however, no necessary index of future possibilities. The most feasible way of obtaining power by electricity to-day seems to be through distribution of the current from a central point of supply; but it is not impossible that a battery may yet be produced which, furnishing electricity as cheaply as a machine, will remove the need of distribution, and at the same time greatly enlarge its field of usefulness.

THE VALUE OF ACCOMPLISHMENTS.

By WILLIAM A. EDDY.

SEVERAL years ago, Dr. Bellows delivered an able address at an annual meeting of the Mercantile Library Association of New York, in which he claimed that literary culture had increased the business capacity of the clerks who used the library. This will be readily admitted. But the question of improvement has moral significance aside from the advantage of a certain quickness or readiness of thought due to mental discipline. It is a law of the mind as well as of the physical structure that repetition of original or skillful action results in increased strength and efficiency, or in a stronger tendency to follow higher forms of thought and amusement. It is true that the proportion of moral action—that which is sane and proper to the mind—can not be represented arithmetically. Nevertheless, the higher kinds of thought may occupy in a general way an increasingly large proportion of the available time. But, as we can not set a definite limit, it is evident that at the present stage of development we are not justified in concluding that any system for displacing immorality can result in anything like perfection; all we can claim is that—taking a vast general average—higher tastes lessen the action of lower. The question of proportion is not so important, however, as the supremacy of a tendency, which in nature sometimes results in immense accumulations of power.

Men are at present in a state of imperfect self-control, and it is necessary that recreation should involve improvement, not only by keeping them out of mischief, but by establishing higher tastes. It is a gratifying fact that there is pleasure in any exercise of skill in art, in its subdivisions of sculpture, music, literature, or in the wonderful manifestations of natural phenomena inadequately grasped by the sciences. The enthusiasm with which art and science are usually followed is like that seen in children who carry out an original idea during play. The higher forms of action are thus spontaneous, and involve originality and force. This applies to small accomplishments as well as great—from the construction of ingenious devices for exhibition at a country fair to the work of Shakespeare, Beethoven, and Michael Angelo.

The great names of the world must not induce us to lose sight of the seemingly trifling manifestations of this force seen in original work followed according to liking, and known as accomplishments. It is to be regretted that this spontaneous action so rarely finds that full expression observed in men of genius in whom it overflows all bounds or obstacles. Some conditions can not be modified, so that

this originality must appear as recreation after the necessary mechanical work of the day is done. The obstacles tending to check independent action are innumerable, and sometimes absolutely insurmountable. A person may be deficient mentally owing to qualities inherited from a long line of stupid ancestors who manifested what Dickens calls "faint gleams of intelligence." In fact, objective events or objects that sweep into personal relation with us from out of vast extents of time and space are more modifiable by us than the almost unalterable conditions arising from hereditary qualities. The lack of power in a given direction may be practically beyond remedy, because very often there is not time in the life of one person for a form of force to reach anything more than primary stages of development. In special classes such limitation can recede greatly only in the course of generations in descendants who finally realize the ideal of Jean Paul Richter—the happy condition of liberty when sport is of service to the race.

Accomplishments are usually considered sources of amusement, although they must be paid for with a varying proportion of exertion not particularly pleasurable. In those forms of recreation in which we are mere passive spectators—often necessary as a relief from toil —there is an inevitable payment of either money, time, or labor. But, where the labor and sport are one, there is obviously a double reward.

It may be noticed, as a further extension of this truth, that the active or positive amusements are superior to the passive, for the reason that the passive do not stimulate the mind to conscious activity. There may be a high form of amusement as well as valuable mental discipline in the production of ingenious designs—such as articles for decoration, various products of carpentry-work, mechanical devices, chemical experiments, and so on. It is important to remember that some who have thus followed a liking for scientific or other knowledge have been stimulated to undertake tremendous feats of perseverance, whereby their names have lived for centuries.

The language learned and the skill acquired in painting or music seem trivial, but they establish an original habit of thought which incites others by force of example. Accomplishments indicate energy of character, for their pleasurable effect is largely due to a sense of power from having triumphed over obstacles.

In a world in which we are environed by dangers and mischances, every form of perseverance is honorable because it is either directly or indirectly helpful. The advances in enlightenment have come, not from those who are mechanical and passive, but from those of original force, who had ingenuity and other allied qualities by which practical effects are produced.

DARWIN ON THE MOVEMENTS OF PLANTS.

By ELIZA A. YOUMANS.

SINCE the time of Linnæus, men have wondered and speculated about what are known as the spontaneous movements of plants, and in recent years the causes of these movements have been carefully investigated by botanists. The subject in its various bearings now forms a large part of the science of vegetable physiology. The periodical and irritable motions of plants, and those due to light and gravity, have been closely studied in connection with the mechanical laws of growth, and many of these phenomena have been more or less satisfactorily explained.

But it has been reserved for Mr. Charles Darwin to go deeper into the facts and philosophy of the subject than any of his contemporaries. In 1875 he published a book upon "The Movements and Habits of Climbing Plants"; and he has since extended his inquiries so as to include the movements manifested by the entire vegetable series, except the lowest flowerless plants, and upon these he is now engaged. He has just published an account of these researches in a volume of six hundred pages, uniform with his other works.

One of the movements of plants long ago observed was described by the term *nutation*, which simply means nodding. The motion of a flower in following the apparent movement of the sun from the east in the morning to the west in the evening is an example of nutation, and this kind of motion has been found to be much more extensive in plants than was formerly supposed.

When we observe the growing stem of the hop, after the first two or three joints are formed, we see it bend to one side and travel slowly round toward all points of the compass, and continue these revolutions day and night. This spontaneous gyrating motion of stems and tendrils was first remarked by Palm and Mohl, and Professor Sachs gave it the name of *revolving nutation*.

Mr. Darwin has found that this kind of motion is ever present in the growing parts of plants, so that it must be regarded as a universal property of growing vegetation, and he suggests for it the better term *circumnutation*. He has proved that even the buried stems and rootlets of germinating seeds make this movement so far as the surrounding pressure will permit.

By the most ingenious and delicate contrivances, and his own constant coöperation, Mr. Darwin has made it possible for the circumnutating organs themselves to indicate approximately the direction and extent of their movements. His arrangements for enabling organs to record their motions varied somewhat; but we give his own account of the general process:

"Plants growing in pots were protected wholly from the light, or had light admitted from above, or on one side, as the case might require, and were covered above by a large horizontal sheet of glass, and with another vertical sheet on one side. A glass filament, not thicker than a horse-hair, and from a quarter to three quarters of an inch in length, was affixed to the part to be observed by means of shellac dissolved in alcohol, which was so thick as to set hard in two or three seconds; and it never injured the most delicate tissues. To the end of the glass filament an excessively minute bead of black sealing-wax was cemented, below or behind which a bit of card with a dot was fixed to a stick driven into the ground. The weight of the filament was so slight that even small leaves were not perceptibly pressed down. The bead and the dot on the card were viewed through the glass plate, and when one exactly covered the other a dot was made on the glass plate with a sharply pointed stick dipped in Indian ink. Other dots were made at short intervals, and they were afterward joined by straight lines. The figures are therefore angular. If the dots had been made every one or two minutes, the lines would have been more curved, as when radicles traced their own courses on smoked-glass plates. When the dot on the card was half an inch from the bead of sealing-wax, and the glass plate (supposing it to have been curved) stood seven inches in front, the tracing represented the movement of the bead magnified fifteen times."

Another, and in some respects better, method was used when it was required to magnify the movement. The dots on the glass plate were copied upon tracing-paper, and joined by ruled lines with arrows to show direction, the first dot being made larger to catch the eye. Night movements are shown by broken lines.

Chapter I is devoted to the circumnutating movements of germinating plants or seedlings. The first experiment relates to the movements of the young rootlet or radicle of a seedling cabbage. In this case fuller details of the process are given, along with the diagram, than in any other, for which reason we reproduce it here.

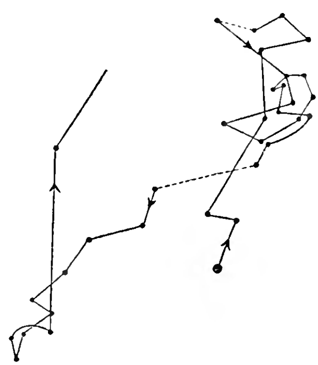


FIG. 1.—BRASSICA OLERACEA: circumnutation of radicle, traced on horizontal glass, from 9 A. M., January 31st, to 9 P. M., February 2d. Movement of bead at end of filament magnified about forty times.

"A seed, with the radicle projecting ·05 inch, was fastened with shellac to a little plate of zinc, so that the radicle stood up vertically; and a fine glass filament was then fixed near its base, close to the seed-coats. The seed was surrounded by bits of wet sponge, and the movement of the bead at the end of the filament was traced (Fig. 1) during sixty hours. In this time the radicle increased in length from ·05 to ·11 inch. Had the filament been attached at first close to

the apex of the radicle, and if it could have remained there all the time, the movement exhibited would have been much greater, for at the close of our observations the tip, instead of standing upward, had become bowed downward, through geotropism [gravitation], so as almost to touch the zinc plate. As far as we could roughly ascertain by measurements made with compasses on other seeds, the tip alone, for a length of only $\frac{2}{100}$ to $\frac{3}{100}$ of an inch, is acted on by geotropism. But the tracing shows that the basal part of the radicle continued to circumnutate irregularly during the whole time. The actual extreme amount of movement of the bead at the end of the filament was nearly ·05 inch, but to what extent the movement of the radicle was magnified by the filament, which was nearly three fourths of an inch in length, it was impossible to estimate. . . .

"Another seed was treated and observed in the same manner, but the radicle in this case protruded ·1 inch, and was not fastened so as to project quite vertically upward. The filament was fixed close to its base. The tracing (Fig. 2, reduced one half) shows the movement

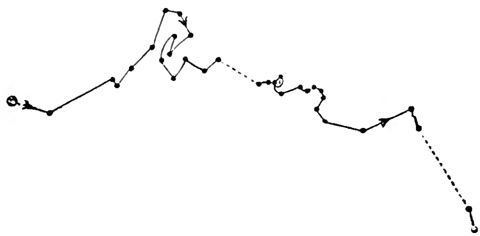


Fig. 2.—Brassica Oleracea: circumnutating and geotropic movement of radicle, traced on horizontal glass during forty-six hours.

from 9 A. M., January 31st, to 7 A. M., February 2d; but it continued to move during the whole of the day in the same general direction and in a similar zigzag manner." The chapter contains fifty-four diagrams, giving the movements of all the parts of the seedlings of all sorts of plants.

Mr. Darwin thinks that these movements of the radicle are useful at least in enabling it to take the line of least resistance, if they do not directly aid it in forming a passage for itself; and he adds: "If, however, a radicle in its downward growth breaks obliquely into any crevice, or a hole left by a decayed root, or one made by the larva of an insect, and more especially by worms, the circumnutating movement of the tip will materially aid its descent; and we have observed that roots commonly run down the old burrows of worms." He says, further, that the force due to longitudinal and transverse growth materially assists the radicle in penetrating the ground. He experimented upon these points, and we give two of these experiments which relate to the force exerted transversely by the radicles of beans. We may say that these radicles have a sharp apex protected by a root-cap, and their growing part is more rigid than the part just above.

A stick cut in the shape of Fig. 3 was purposely split at the short end, the split reaching beyond the hole. As the wood was highly

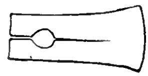


FIG. 3.—OUTLINE OF PIECE OF STICK (reduced to one half natural size), with a hole through which the radicle of a bean grew. Thickness of stick at narrow end, ·08 inch; at broad end, ·16. Depth of hole, ·1 inch.

elastic, the split closed as soon as it was made. The stick and bean were buried in damp sand, the bean being placed so that the radicle in growing would enter this hole. After six days they were dug up, and the radicle was found much enlarged above and beneath the hole. The fissure was open to a width of four millimetres, but as soon as the radicle was removed it closed to two m.m. The stick was then suspended horizontally by a fine wire passing through the hole, and a little saucer was suspended beneath it to receive the weights, and it required eight pounds eight ounces to open the fissure to the width of four m.m.

Again, "holes were bored near the narrow end of two wooden clips or pincers (Fig. 4), kept closed by brass spiral springs. Two radicles in damp sand were allowed to grow through these holes. The pincers rested on glass plates, to lessen the friction from the sand. The holes were a little larger and considerably deeper than in the trials with the sticks, so that a greater length of a rather thicker radicle exerted a transverse strain. After thirteen days they were taken up. The distance of two dots (see Fig. 4) on the longer ends of the pincers was now carefully measured; the radicles were then extracted from the holes, and the pincers of course closed. They were then suspended in the same way as the stick, and a weight of three pounds four ounces was necessary with one of the pincers to open them as much as the radicle had done by transverse growth." This radicle had escaped beyond the hole, and flattened a little, as soon as it had slightly opened the pincers, which had somewhat lessened the strain. As a result of all his observations, he concludes: The radicle "increases in length with a force equal to the pressure of at least a quarter of a pound, and much greater when prevented from bending"; and "it increases in thickness, pushing away the damp earth on all sides with a force of above eight pounds in one case and three pounds in another."

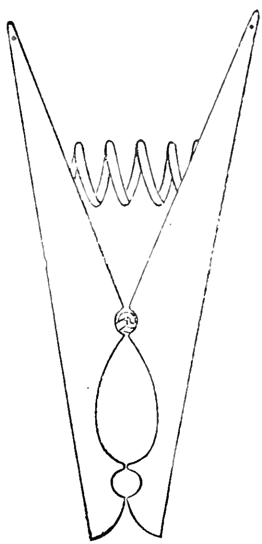


FIG. 4.—WOODEN PINCERS, KEPT CLOSED BY A BRASS SPIRAL SPRING, with a hole (·14 inch in diameter and ·6 inch in depth) bored through the narrow closed part, through which a radicle of a bean was allowed to grow. Temperature, 50°-60° Fahr.

To determine whether the growing parts of mature plants circumnutate, Mr. Darwin experimented with the representatives of about twenty genera, belonging to widely different families and various countries. Several woody plants were chosen, as being less likely to circumnutate. Plants in pots were kept at a proper temperature, either in darkness or feebly illuminated from above. Diagrams showing the circumnutation in about fifty instances of runners or stolens, flower-stems, leaves young and old, leaflets, fronds, etc., are given, and the volume contains about a hundred and fifty such diagrams, accompanied by explanations and comments bearing upon the argument of the book. The published instances are selected, for one reason and another, from an accumulation of similar material, the result of years of observation. The figures made by stems, which were always growing, are of course somewhat spiral, forming a succession of more or less irregular narrow ellipses, with their longer axes directed to different points of the compass at different times. They show that the course pursued is often interrupted by zigzags, loops, and small triangles. The rate of movement was different at different times and with different plants. Some made but one ellipse a day, and others four or five.

In studying leaves, he experimented with from thirty to forty widely distributed genera of dicotyledons, monocotyledons, and cryptogams. The seat of movement, he found, was generally in the petiole, but sometimes also in the blade. The extent of movement differed greatly. It is chiefly in a vertical plane; but, as the ascending and descending lines never agreed, there was always some lateral motion describing irregular ellipses. These observations were made upon healthy plants growing in pots, illuminated from above, many of them through ground glass, and they were also plants that do not sleep at night. The stem was always secured to a stick close to the base of the leaf under experiment. Besides his general conclusion that all growing parts circumnutate, many other important inferences are drawn by the author from these experiments and observations.

This movement, which in the case of climbing plants was believed to be due to increased growth of the side that for the time became convex, has more recently been proved to result from the circumstance that every part of a plant while it is growing, and in some cases after growth has ceased, has its cells rendered more turgescent and its cell-walls more extensile first on one side and then on another. Why this should be the case is not known, but Darwin suggests that the changes in the cells may require periods of rest, which accords with our knowledge of the rhythmical nature of motion.*

Under the microscope, this movement of circumnutation was seen in a few cases to be made up of sudden small jerks forward for ·002

* For an interesting and extended discussion of this subject, the reader is referred to the chapter on the mechanical laws of growth in Sachs's "Text-Book of Botany."

or ·001 of an inch, and then a slow retreat for part of the distance. No such movement could be detected with a two-inch object-glass, in the case of Drosera, and how far it is general is not known. Mr. Darwin says: "The whole hypocotyl (stem of a cotyledon) of a cabbage or the whole leaf of a Dionæa * could not jerk forward unless a very large number of cells on one side were simultaneously affected. Are we to suppose that these cells steadily become more and more turgescent on one side, until the part suddenly yields and bends, inducing what may be called a microscopically minute earthquake in the plant; or do the cells on one side suddenly become turgescent in an intermittent manner—each forward movement thus caused being opposed by the elasticity of the tissues?"

Mr. Darwin has shown the importance of this ever-present movement in successive chapters upon *modified* circumnutation. By this phrase he means that pressure and other irritants, light and gravitation, do not directly cause movement; they only modify the spontaneous changes in the turgescence of the cells, which are always in progress, and of which circumnutation is a universal consequence. He thinks that, in the case of seedlings, ordinary or unmodified circumnutation is clearly of service, directly or indirectly; but, in the later stages of growth, it is from various modifications of this constant motion that the plant derives benefit.

More than half the volume is given to the modifications of circumnutation by *epinasty* and *hyponasty*; † by nyctitropic or sleep-movements; and by the influence of light and of gravitation: but we can only glance at one of these, which is popularly styled the sleep of leaves, although there is probably no real analogy between the sleep of animals and that of plants.

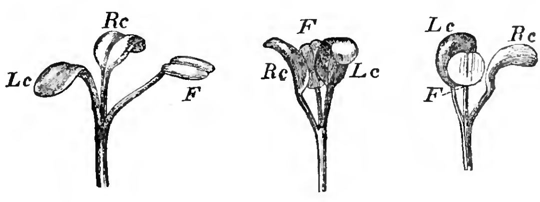


FIG. 5.—TRIFOLIUM STRICTUM: DIURNAL AND NOCTURNAL POSITIONS OF THE TWO COTYLEDONS AND OF THE FIRST LEAF: I. Seedling viewed obliquely from above, during the day: *Rc*, right cotyledon; *Lc*, left cotyledon; *F*, first true leaf. II. A rather younger seedling, viewed at night: *Rc*, right cotyledon raised, but its position not otherwise changed; *Lc*, left cotyledon raised and laterally twisted; *F*, first leaf raised and twisted so as to face the left twisted cotyledon. III. Same seedling viewed at night from the opposite side. The back of the first leaf, *F*, is here shown instead of the front, as in II.

Nyctitropic (*night-turning*) is the word used by Darwin to describe the sleep of leaves and occasionally of flowers, but, as flowers are affected chiefly by changes of temperature instead of light, their

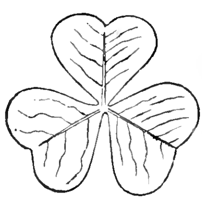
* In these instances the jerking motions were very remarkable.

† The alternately more rapid growth of the upper and under surfaces of organs.

sleep does not so much concern the inquiry. The night-movements of leaves result from circumnutation modified by changes of light and darkness, and also by heredity; and, as Darwin has proved, they are chiefly of use to the plant in diminishing the loss of heat by radiation. Therefore, he says, no movement deserves to be called nyctitropic unless it has been acquired for this purpose. As some leaves and cotyledons bend upward only a little at night, the question arises, At what angle does the diminished radiation warrant the use of this term? He takes an arbitrary limit of 60°, above or below the horizon, as any less angular rise and fall would be of slight significance. Nyctitropic movements are easily affected by surrounding conditions of moisture and temperature, and in many genera it is indispensable that the leaves should be well illuminated during the day. From the very wide list of genera experimented upon, it follows that the habit of sleeping "is common to some few plants throughout the whole vascular series."

Darwin first considers the sleep of cotyledons, having observed the positions during the day and night of the representatives of one hundred and fifty-three genera. Some ten pages are given up to remarks upon this subject. We give his account of the behavior of the cotyledons of *Trifolium strictum* as it is illustrated by a picture of the diurnal and nocturnal positions they assume.

"On the first day after germination, the cotyledons stood at noon horizontally, and at night rose to only about 45° above the horizon. Four days afterward the seedlings were again observed at night, and now the blades stood vertically and were in contact, excepting the tips, which were much deflexed, so that they faced the zenith. At this age the petioles are curved upward, and at night, when the bases of the blades are in contact, the two petioles form a vertical ring around the plumule. The cotyledons continued to act in nearly


A.


B.

FIG. 6.—OXALIS ACETOSELLA: A, leaf seen from vertically above; B, diagram of leaf asleep, also seen from vertically above.

the same manner for eight or ten days from the time of germination, but the petioles had become straight and were much lengthened. After twelve or fourteen days the first true leaf was formed, and during the next fortnight a remarkable movement was repeatedly observed. At I, Fig. 5, we have a sketch made in the middle of the day, of a seedling a fortnight old. The two cotyledons, of which

Rc is the right, and *Lc* the left one, stand directly opposite one another, and the first true leaf (*F*) projects at right angles to them. At night (see II and III) the right cotyledon (*Rc*) is greatly raised, but is not otherwise changed in position. The left cotyledon (*Lc*) is likewise raised, but it is also twisted so that its blade, instead of exactly facing the opposite one, now stands at nearly right angles to it. This nocturnal twisting movement is effected by the twisting of the whole length of the petiole. At the same time the true leaf (*F*) rises up vertically, or even inclines inward. It also twists a little, so that the upper surface of its blade fronts the upper surface of the twisted left cotyledon. The whole case is remarkable, as with the cotyledons of no other plant have we seen any nocturnal movement except vertically upward or downward."

The various ways in which the leaves of plants are protected from loss of heat by radiation at night are shown by diagrams and pictures from which we select some of the most striking. A good deal of space is given to an account of the circumnutation and nyctitropic movements of the *Oxalidæ.* In most of the species of oxalis the three leaflets sink vertically down at night. But, as their sub-petioles are short, the blades could not assume this position from want of space, unless they were in some manner rendered narrower, and this is effected by their becoming more or less folded (Fig. 6), so that their lower surfaces are brought near together (see B), as if the object were their protection rather than that of the upper surface. This would form a marked exception to the rule, that the object of sleep is protection of the upper surfaces from radiation, if it had not been found that, in species where the sub-petioles are longer, the leaflets sink without folding together. By thus crowding together at night, a much smaller surface is exposed than during the day.

A. B.

Fig. 7.—Medicago marina : A, leaves during the day ; B, leaves asleep at night.

"The drawing of *Medicago marina*, awake and asleep (Fig. 7), answers almost as well for *Cytisus fragrans*, which rose at night on one occasion 23° and on another 33°. The three leaflets also bend upward, and at the same time approach each other so that the base of the central leaflet overlaps the bases of the two lateral leaflets. They

bend up so much that they press against the stem; and, on looking down on one of these young plants from vertically above, the lower surfaces of the leaflets are visible: and thus their upper surfaces, in accordance with the general rule, are best protected from radiation. While the leaves on this young plant were thus behaving, those on an old bush in full flower did not sleep at night."

Again, "the species of Melilotus sleep in a remarkable manner. The three leaflets of each leaf twist through an angle of 90°, so that their blades stand vertically at night, with one lateral edge presented to the zenith" (Fig. 8). We have no room for the description of the

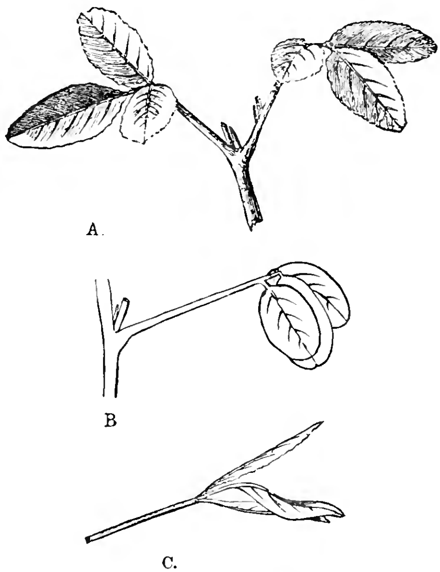


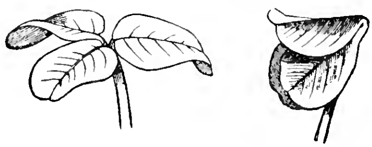
Fig. 8.—Melilotus officinalis: A, leaf during the daytime; B, another leaf asleep; C, a leaf asleep as viewed from vertically above, but in this case the terminal leaflet did not happen to be in such close contact with the lateral one as is usual.

complicated movements performed by these plants. Their petioles and sub-petioles are continually circumnutating during the whole twenty-four hours. Their cotyledons do not sleep.

The nyctitropic movements of eleven species of Trifolium were observed and were found to be closely similar. If we select a leaf of *Trifolium repens* having an upright petiole and with the three leaflets expanded horizontally, the two lateral leaflets will be seen in the evening to twist and approach each other until their upper surfaces come into contact. At the same time they bend downward in a plane at right angles to their former position, until their midribs form an angle of about 45° with the upper part of the petiole. The terminal leaflet merely rises up without any twisting, and bends over until it rests on and forms a roof over the edges of the now vertical and united lateral

leaflets, as seen in Fig. 9, with its lower surface fully exposed to the zenith.

The nyctitropic movements of ten species of the lotus tribe were observed and found to be alike. The main petiole rises a little at night, and the three leaflets rise till they become vertical, and at the



A. B.

FIG. 9.—TRIFOLIUM REPENS: A, leaf during the day; B, leaf asleep at night.

same time approach each other. In most of the species the leaflets rise so much as to press against the stem, and not rarely they become inclined a little inward, with their lower surfaces exposed obliquely to the zenith. The young leaves on the summits of the stems close up at night so much as often to resemble large buds. The stipule-like leaflets,

A. B.

FIG. 10.—LOTUS CRETICUS: A, stem with leaves awake during the day; B, with leaves asleep at night; *ss*, stipule-like leaflets.

which are often of large size, rise up like the other leaflets, and press against the stem (see Fig. 10). The circumnutation of a terminal leaflet (with the stem secured) was traced during two days, but the move-

ment was so simple that it is not worth while to give the diagram. The leaflet fell slowly from the early morning till about 1 P. M. It then rose gradually at first, but rapidly late in the evening. It occasionally stood still for some twenty minutes during the day, and sometimes zigzagged a little.

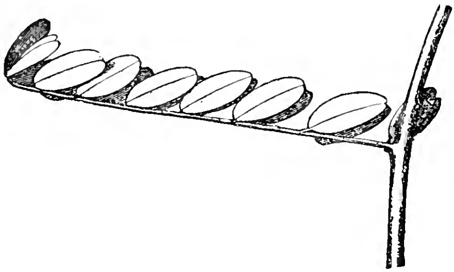
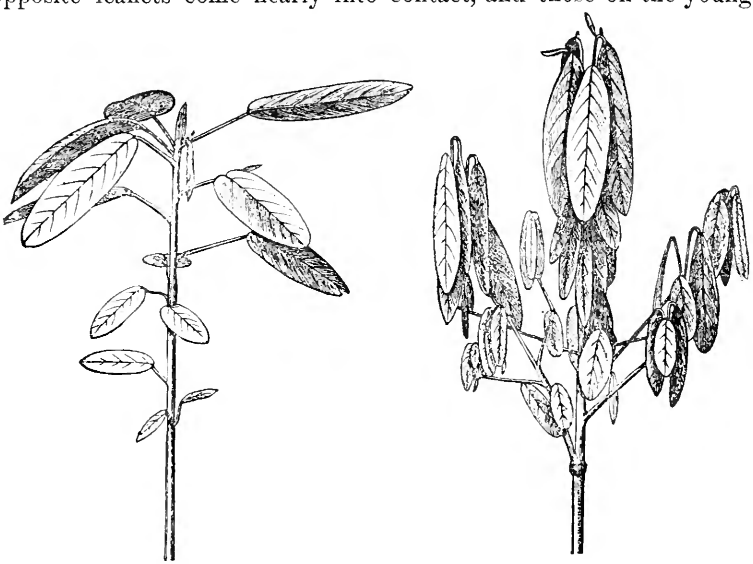


FIG. 11.—CORONILLA ROSEA: Leaf asleep.

The leaves of *Coronilla rosea* bear nine or ten pairs of opposite leaflets, which during the day stand horizontally, with their midribs at right angles with the petiole. At night they rise up, so that the opposite leaflets come nearly into contact, and those on the younger



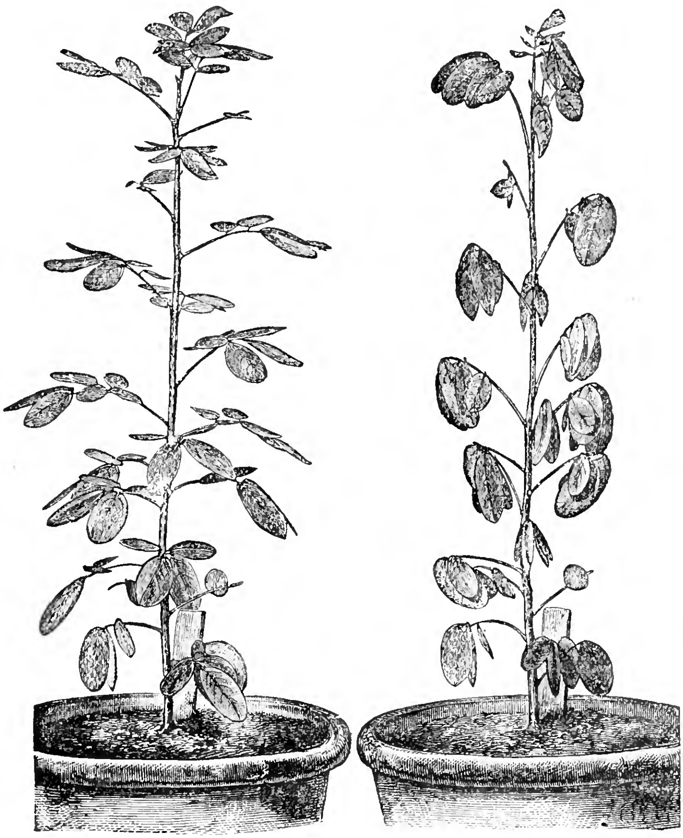
A. B.

FIG. 12.—DESMODIUM GYRANS: A, stem during the day; B, stem with leaves asleep. Copied from a photograph; figures reduced.

leaves into close contact. At the same time they bend back toward the base of the petiole until their midribs form with it angles of from 40° to 50° in a vertical plane (as in Fig. 11).

The appearance presented by a sleeping branch of *Desmodium gyrans* and by one in the daytime, copied from two photographs, is

shown at A and B (Fig. 12), where the leaves are seen at night crowded together, as if for mutual protection. Not less striking is the contrast between the night and day aspect of *Cassia corymbosa*, as seen in Fig. 13. Here the horizontally extended leaflets sink down vertically at night, and at the same time rotate so that the lower surface faces outward.



A. B.

Fig. 13.—Cassia corymbosa: A, plant during day; B, same plant at night. Both figures copied from photographs.

As a conclusion from all his experiments, observations, and reflections upon this subject, Mr. Darwin states:

"The great sweeps made by the stems of twining plants, and by the tendrils of other climbers, result from a mere increase in the amplitude of the ordinary movement of circumnutation. The position which young leaves ultimately assume is acquired by the circumnutating movement being increased in some one direction. The leaf-blades of various plants assume a vertical position through modified circumnutation, in order to protect their upper surfaces from being chilled

through radiation. The movements of various organs to the light, which are so general throughout the vegetable kingdom, and occasionally from the light, or transversely with respect to it, are all modified forms of circumnutation, as again are the equally prevalent movements of stems, etc., toward the zenith, and of roots toward the center of the earth. In accordance with these conclusions, a considerable difficulty in the way of evolution is in part removed, for it might be asked, How did all their diversified movements for the most different purposes first arise? As the case stands, we know that there is always movement in progress, and its amplitude or direction, or both, have only to be modified for the good of the plant, in relation with internal or external stimuli."

The discovery of the sensitiveness of the apex of the radicle was made by Darwin when he was looking for something else. Wishing to know how the radicles of seedlings passed over obstacles in the ground, he placed germinating beans in such a way that the tips of

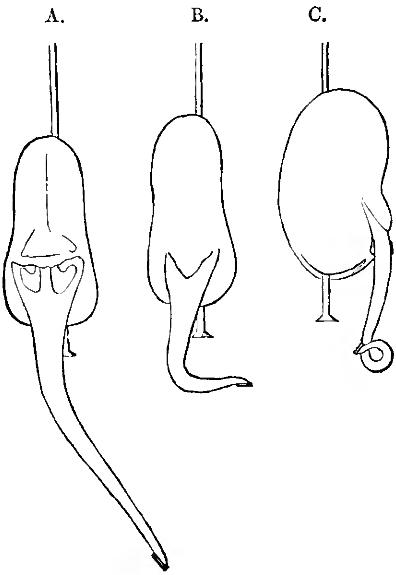
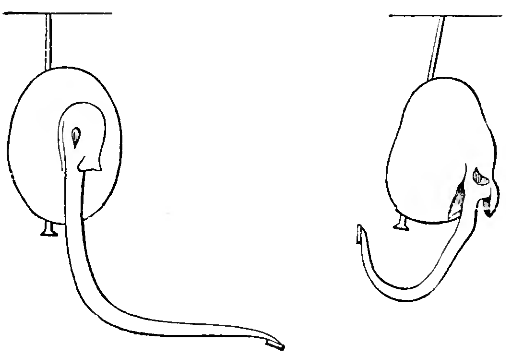


FIG. 14.—VICIA FABA: A, radicle beginning to bend from the attached little square of card; B, bent at a rectangle; C, bent into a circle or loop, with the tip beginning to bend downward through the action of geotropism.

the radicles came into contact with opposing surfaces at a high angle. When the root-cap touched such an obstacle it was at first a little flattened, but this flattening soon disappeared, and the apex took a direction at right angles to its former course. Straight lines had been painted along the growing terminal part of some of these radicles before they met the opposing objects, and the lines became sensibly curved in two hours after the apex had come into contact with them. The explanation of this curvature of the growing part could not be me-

chanical resistance, because it occurred when there was not pressure enough to produce it ; and, besides, Sachs has shown that the growing part is more rigid than the part just above it, which should have yielded first to resistance. Moreover, objects that yield with the greatest ease will deflect a radicle. After various attempts to explain the phenomenon, Darwin was led to suspect that the tip was sensitive to contact, and that it transmitted an effect to the upper part of the radicle, so exciting it to bend away. Such a thing had never been suspected, although Sachs discovered that the radicle is sensitive a little above the apex, and bends, like a tendril, *toward* the touching object.

Full details are given of the experiments by which this suspicion was verified. We can only say, briefly, that "germinating beans were pinned hilum downward inside the well-moistened cork lids of glass vessels which were half filled with water, and the light excluded. When the protruding radicles were the tenth of an inch or more long, bits of card about one twentieth of an inch square, or bits of sand-paper, were affixed to the sloping sides of their tips by means of thick gum-water, which by itself had no effect. To avoid confusion from the bending known as Sachs's curvature, the bits were never put in front." That the reader may have a clear idea of the kind of movement excited by the bits of card, we give, Fig. 14, sketches of three beans thus treated, which show the gradations in the degree of curvature. Out of fifty-five beans experimented upon, fifty-two were considerably bent away from the object attached, and the remaining three seemed to become sickly. As the radicle of the pea

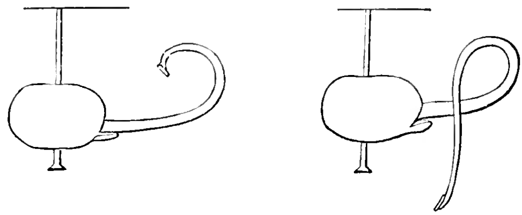


A. B.

FIG. 15.—PISUM SATIVUM: Deflection produced within twenty-four hours in the growth of vertically dependent radicles, by little squares of card affixed with shellac to one side of the apex: A, bent at right angles ; B, hooked.

was found to be rather more sensitive at a point above the apex than that of the bean, he experimented with twenty-eight peas which had been soaked for twenty-four hours, and then left to germinate in damp sand. He tried them first with bits of card above the apex for Sachs's curvature, and thirteen of them bent toward the card, the greatest curvature being 62°. Bits of card were then fastened to one side of

the tips of eleven radicles within the same jars, and five of them became plainly curved away from this side. In the former case the bend was abrupt, as shown in Fig. 15; in the latter a greater length of radicle

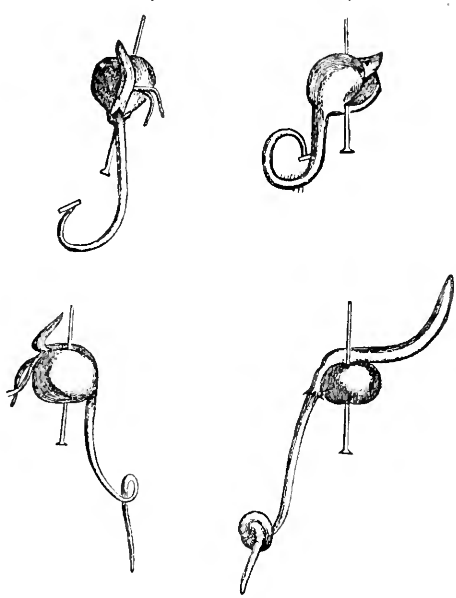


A. B.

Fig. 16.—Pisum sativum.—A radicle extended horizontally in damp air with a little square of card affixed to the lower side of its tip, causing it to bend upward in opposition to geotropism. The deflection of the radicle after twenty-one hours is shown at A, and of the same radicle after forty-five hours at B, now forming a loop.

seemed to be affected and the curve was symmetrical, as seen in Fig. 16. He says, "It was a striking spectacle, showing the difference in the sensitiveness of the radicle in different parts, to behold in the same

A. B.



C. D.

Fig. 17.—Zea mays: Radicles excited to bend away from the little squares of card attached to one side of their tips.

jar one set of radicles curved away from the squares on their tips, and another set curved toward the squares attached a little higher up."

His experiments upon the radicles of dicotyledons were numerous and varied in every way; but the seeds of Indian corn were the only

monocotyledonous ones which he observed. Omitting particulars, the cuts (Fig. 17) will show the effects produced in four instances.

In the case of A, the apex of the radicle is so much bent away from the square as to form a hook. At B, the irritation of the card, aided, perhaps, by geotropism, has formed a circle. At C, the tip in forming a loop has rubbed off the attached bit, and the circle has contracted, while at D, the apex, in making a second turn, passed through the first loop and so rubbed off the card, and, growing downward, tied itself into a knot.

Mr. Darwin believes that the tips of all radicles are similarly sensitive, and transmit an influence causing the upper part to bend. Moreover, the tip distinguishes between harder and softer objects, and between moisture and dryness. It is also sensitive to light and gravitation, and the course of the radicle in the ground is determined by the tip. The volume concludes with the following sentence: "It is hardly an exaggeration to say that the tip of the radicle thus endowed, and having the power of directing the movements of the adjoining parts, acts like the brain of one of the lower animals; the brain, being seated within the anterior end of the body, receiving impressions from the sense-organs and directing the several movements."

ATMOSPHERIC ELECTRICITY.

By Professor H. S. Carhart.

FROM the earliest periods the flash of lightning and the peal of thunder have excited curiosity, stimulated awe, and inspired fear in man; and according to his mythological, religious, or poetic habit of mind has he regarded the latter as the bolt of Jove, the voice of God, or the conscious utterance of the heavens. The explanation of these appearances in the sky is most curious and fantastic, even after the introduction of the modern inductive method. In a "Compendious System of Natural Philosophy," by J. Rowning, M. A., London, 1744, we find the following: "As vapors exhaled from the surface of water are carried up into the atmosphere, in like manner the *effluvia* of solid bodies are continually ascending thither. Now, we find by experiment that there are several inflammable bodies which, being mixed together in due proportion, will kindle into flame by fermentation alone, without the help of any fiery particles. When, therefore, there happens to be a mixture of the effluvia of such bodies floating in the air, they ferment, kindle, and, flashing like gunpowder, occasion those explosions and streams of fire which we call thunder and lightning."

Ever since Franklin identified lightning with the electricity of the frictional machine, an inquiry has been prosecuted into the origin of

atmospheric electricity. It has been ascribed to chemical action in vegetation, without any basis of proof; also with more reason to evaporation and to friction of solid and liquid particles against bodies on the surface of the earth. But friction fails to account for the fact that electrical displays, other than auroral ones, occur only during heavy precipitation of hail or rain, except in mountainous districts.

Deferring for the present what appears to be a probable account of the generation of atmospheric electricity, we may profitably review certain facts established by observation and experiment.

It is a matter of common observation that a small ascending jet of water is resolved into drops, which describe widely divergent trajectories. By reason of the different velocities and directions of motion of the individual drops, they come into frequent collision with one another and then rebound. The influence of electricity on the recoil of the drops after collision is most marked and interesting. About two years ago, Lord Rayleigh read a paper before the Royal Society on this subject, setting forth the results of his experiments.

When the ascending jet is strongly electrified, the drops do not collide, because of their mutual repulsion, arising from their charge of electricity of like sign. But with a very feeble charge the drops coalesce upon impact, and the breaking up of the stream is thereby much lessened. The rubbing of a glass rod across the sleeve in the vicinity of the jet suffices to prevent the rebound after collision; as also does the current from a single Grove element.

Further experiments, in which one of two contiguous jets was electrified, proved that the coalescence was due to a slightly different degree of electric tension in the impinging particles of water. In such case their attraction and coalescence are determined by static induction, the resulting force of which is always attractive; and with slight electrification the inductive effect always prevails over the repulsion due to like charges, when the charged bodies are brought near together. Hence strongly electrified particles do not actually collide, but are kept apart by electrical repulsion; while those feebly charged approach within the charmed circle where the attraction of static induction determines their collision and coalescence.

The bearing of these facts upon precipitation of aqueous vapor is obvious. Innumerable globules of water, feebly charged to different potentials, inevitably collide and coalesce into drops, which descend by gravity. A slight amount of electricity in the atmosphere is therefore favorable to aqueous precipitation, while a higher degree of electrical excitation is unfavorable to rapid condensation.

It is important in this connection to point out another conclusion bearing upon condensation of vapor—a conclusion reached by applying mathematics to the theory of electrified spheres or drops of water. An explanation of terms is essential to an understanding of the reasoning.

We have already employed the term "potential," a word of frequent occurrence in modern electrical works. An insulated, charged conductor exerts influence in every direction about it. The term "electrical potential" expresses the value of that influence at any specified point where there is electrical force. When any force acts, energy is expended in doing work; and the numerical value of the scientific expression "work" is the measure of the energy expended or the resistance overcome. "Work" means the product of the force into the distance over which it acts. The lifting of five pounds through a distance of ten feet requires the expenditure of fifty foot-pounds of work. Hence "electrical potential" may be defined in terms of work as follows: *The electrical potential at any point is the work required to carry a unit of electricity from that point to infinity.* It is of course understood that the "unit of electricity" is carried against the attraction due to an electrified body.

Potential is accordingly a mathematical and exact expression for all the work possible to be done against the attraction of a given amount of electricity resident at some specified place. In exactly the same way gravitational potential at any point may be defined as the work required to carry a unit mass of matter from that point to infinity against the attraction of gravitation.

Electrometers have been constructed by Sir William Thomson, with marvelous skill and inventive genius, designed to measure the potential at any point or of any body. It is susceptible of easy proof that the potential of a sphere, charged with electricity, Q, is everywhere equal to Q divided by its radius R. Further, the *capacity* of a body for electricity is the quantity required to charge it to emit potential; and, as potential varies with the charge, we readily find that the capacity of a sphere is numerically equal to its radius.

To apply this to condensation, suppose that drops of water of unit radius, unit capacity, and unit potential, coalesce to form drops of radius two: what will be the capacity and potential of such larger drops? Since the volume of spheres varies as the cube of their radii, eight of the small drops will be required to make one large one. The large drop will, therefore, contain eight times as much electricity as each of the small ones. As compared with the small drops, its capacity, being equal to its radius, will be only doubled, while its charge will be increased eightfold; and its potential will, therefore, be four times as great as that of the small drops, since potential of a sphere equals quantity of electricity divided by capacity of sphere. If its potential is quadrupled, its inductive influence on other bodies and its tendency to discharge are increased in the same ratio.

When, therefore, condensation occurs, aggregating minute globules of water into larger ones, the electric tension of the mass of descending vapor is immensely increased, without any corresponding increase in the total quantity of electricity present.

These two conclusions, applicable to condensation, may be applied to the frequently observed fact that a vivid flash of lightning is often quickly followed by a sudden and heavy down-pouring of rain. It is clearly impossible to tell which is antecedent to the other, the discharge or the sudden condensation; for, while the flash reaches the observer first, it is clear that light travels from the place of action with a vastly greater velocity than that of the falling rain, and the discharge may therefore have been subsequent to the sudden condensation. If the discharge occurs first, then the lowering of the electric potential permits approach of aqueous spherules and consequent coalescence after collision, in accordance with Lord Rayleigh's experiments. On the other hand, if the condensation is antecedent, it follows from the result reached above that it must be accompanied by a sudden rise of potential in the enlarged drops, leading to an electric discharge.

It will be observed that neither of these principles accounts for the original electrification of aqueous vapor in the air. It has been the custom to regard thunder-clouds as primarily charged by some unexplained process; and these, acting inductively, as producing a corresponding charge of opposite sign in the earth underneath. This view appears to have no conclusive evidence in its favor, but corresponds rather to appearances merely—a very unreliable guide.

In the theory here proposed, the earth is the charged body, acting inductively on the air, aqueous vapor, and clouds about it. Whenever moisture condenses to cloud, a better conductor is thereby formed, and increased inductive action takes place, causing an accumulation of electricity both in the cloud above and the earth beneath. If, then, the lower part of the cloud, under this inductive influence, condenses to rain and falls away from the upper part, a separation of the two electricities is effected, and an increase in potential results from the enlargement of the drops, as explained above. Consequently, a discharge may then take place either between the upper and lower cloudy strata, or between the lower portion and the earth, according as one path or the other offers the least resistance.

Further, when evaporation takes place from an electrified locality, the rising vapor must carry away a charge of electricity by convection, as air and dust carry away electricity from a charged conductor. The condensation of this vapor increases its potential, and, if sufficiently rapid, gives rise to electrical displays. It is a fact of recent establishment that "northern lights" occur in various high latitudes only with southerly winds, which come laden with moisture and probably with electricity.

The following considerations in favor of this view of the origin of atmospheric electricity may be briefly enumerated:

1. Continuous observations of the electrical state of the atmosphere at Kew Observatory and elsewhere for several years show that the air is always more or less electrified. The average potential of

fair weather being + 4, it was found rarely to fall as low as + 1; often during sudden showers it equals ± 20 or ± 30; during snow-storms with high wind it sometimes reaches + 100; and during thunder-showers, ± 100 and even — 200. A predominance of negative electricity is characteristic of thunderstorms. Hence some origin of atmospheric electricity, always operative, but in different degrees of intensity, must be sought. Clearly, any form of energy connected with mere cloud-formation will not answer the requirements.

2. The observations show also that the potential of the air is exceedingly fluctuating, no natural phenomenon being comparable with it in changeableness except wind-pressure. A change in the electrical state of the air indicates a corresponding change in the earth's surface. It is more reasonable to suppose that the earth, the great reservoir of electricity, should control the air and clouds electrically than that the clouds should control the earth.

3. The surface of the earth is perhaps never in electrical equilibrium; in other words, it is not an equipotential surface. Some time about 1865 Matteucci made prolonged experiments on earth-currents, and reached several interesting results. He found, for instance, that a tolerably steady current of electricity flowed through a line established along a meridian, uniformly from south to north; that fluctuating currents of low electromotive force flowed through an east and west line, sometimes in one direction, sometimes in the other; that when one terminal of a long line was in a valley and the other at a considerably higher elevation, a current flowed uniformly up the wire toward the more elevated end. A flash of lightning, in this case, was always accompanied by a sudden increase in the deflection of the galvanometer needle. ("Smithsonian Reports," 1867.)

4. Irregular and spontaneous earth-currents are the usual accompaniment of great terrestrial disturbances. James Graves showed in 1871 that spontaneous currents in the Atlantic cables frequently occur during earthquake-shocks. ("Journal Soc. Tel. Eng.," ii, pp. 80–120.) That spontaneous currents flow through land lines during auroral displays is a well-known fact. It is also asserted that any great meteorological change, as the motion of a heavy storm with considerable barometric fluctuation, is announced at a distance by irregular galvanic shocks through submarine cables.

5. Marked electrical disturbances in the atmosphere not infrequently accompany earthquakes and volcanic eruptions. A vivid flash of lightning was seen during an earthquake-shock in West Cumberland, England, on October 25, 1879. So frequently are these two phenomena conjoined that some writers have attributed South American earthquakes to electrical action. Lightning is often seen playing about the boundary between the condensing vapor from a volcano and the adjacent cool air.

6. Measurements of the potential of the air show that, as we pro-

ceed farther from the surface of the earth, the potential of points in the air differs more and more from that of the earth, the difference being approximately simply proportional to the distance. Also the electrical density is greater on projecting parts of the earth's surface than on those which are plane or concave. These facts are precisely what we should find to be the case in the vicinity of an irregular, charged conductor; and they are sufficiently explained if we regard the earth itself as charged with electricity varying in density. In fact, observations of the potential of so-called atmospheric electricity are simply "determinations of the quantity of electricity residing on the earth's surface at the place of observation." (Professor Everett, in Deschanel's "Natural Philosophy.")

In the Rocky Mountains electrical storms are of frequent occurrence. They consist of electrical displays without precipitation of rain, hail, or snow. Usually, though not always, the sky is overcast. In February, 1880, a remarkable electrical excitation was manifest at Boulder, Colorado. The miners were unable to kindle fire in the stove till eleven o'clock in the morning, every attempt to touch the metal about the stove resulting in a severe electrical shock. With every strong gust of wind the manifestations were more marked. Similar reliable evidence comes to the writer from other parts of Colorado. Long's Peak, an isolated mountain, 14,271 feet high, is noted for these peculiar electrical manifestations. The density of electricity on the peaks, projecting so far above the general level of the earth's surface, is greater than elsewhere; hence they possess a power to discharge like points on an electrified conductor. The air and aqueous vapor become surcharged with electricity; and only a slight condensation, sufficient merely to form clouds without rain, serves to produce discharges of lightning. With heavy gusts of wind the charged air is removed, and a fresh supply is provided into which the peak again pours its electricity.

In view of these facts, the theory is submitted as worthy of consideration that the earth itself is the seat of those disturbances that manifest themselves in atmospheric electricity. Fluctuating currents ebb and flow through the confining walls of this immense reservoir of cosmic energy. These follow naturally from the great changes in temperature to which the earth's crust is subjected; from those seismic disturbances occasioned by vast internal convulsions; from immeasurable local strain and compression, the result of upheaval and contraction. The earth, unlike the moon, contains still a vast store of unexpended energy; and in the ebb and flux of its mighty internal, contending forces, and the bending and swaying of its magnetic lines of force, in obedience to the magic wand of the sun, there is ample room for the generation of those comparatively feeble forms of energy that manifest themselves in the electrical disturbances of the air.

OPTICAL ILLUSIONS OF MOTION.

By SILVANUS P. THOMPSON, B.A., D.SC.

THERE are frequent occasions of conflict between the receptive faculties of the senses and the reflective faculties of the intellect, occasions on which the mind, prejudging of the sensation received, assigns it to a non-existent cause. Of all the senses none is more frequently the seat of such deceptive judgments than that of sight; and in the science of physiological optics a very considerable share of attention is claimed by optical illusions. For the purposes of convenience, we may draw a distinction between these illusions, which are the direct result of certain properties or imperfections of the eye as an optical instrument, and those which arise from obliquities of judgment in interpreting the sensations optically impressed upon the retina of the eye. In practice, however, it is almost impossible to draw a hard-and-fast line between the two classes of illusions, almost all partaking of both characters. Thus, for example, it has lately been shown that we habitually draw geometrical forms too large in the horizontal dimension as compared with their vertical dimension; we draw oblate ellipses where we intend to draw circles; the explanation of this being that with our *two* eyes we really *see* spheres as oblate ellipses. Here is, in fact, an illusion of pure association—yet based upon the facts of physical and physiological optics. So, again, certain inequalities in the curvature of the lenses of the eye, producing the optical defect of astigmatism, cause objects that are horizontal in position to form images at shorter (or longer as the case may be) distances from the eye than the images of vertical objects; the result being that, unless the defect is corrected by suitable lenses, vertical and horizontal objects (such as the bars of a window) do not appear to be at the same distance from the observer, though really equally remote. This would, at first sight, appear to be a purely physical illusion, and not psychological. Nevertheless, a little consideration will show that since our perception of distance is a psychological factor in the case, and that this perception is based in part upon the muscular sensations of adjustment of the lenses of the eye to exact focus, the illusion is one which has a psychological as well as a physical *raison d'être*. Again, take some illusions ordinarily supposed to be one purely of mental association: the common illusion of every day, that the sun or moon when a few degrees from the horizon looks larger than when high in the sky, appears at first sight to be due simply to the fact that when the orb is near the horizon the distant objects upon that horizon whose size we know, or can judge of, appear relatively small, and the sun's disk relatively large—in fact, that the illusion is one purely of association of ideas. Nevertheless, when we look a little closer into the matter, we

find that our simplest conceptions of angular or apparent magnitude are very closely bound up with, if not directly due to, the sensations of muscular fatigue in moving the eyeball or head so as to bring the successive parts of the object into the center of vision.

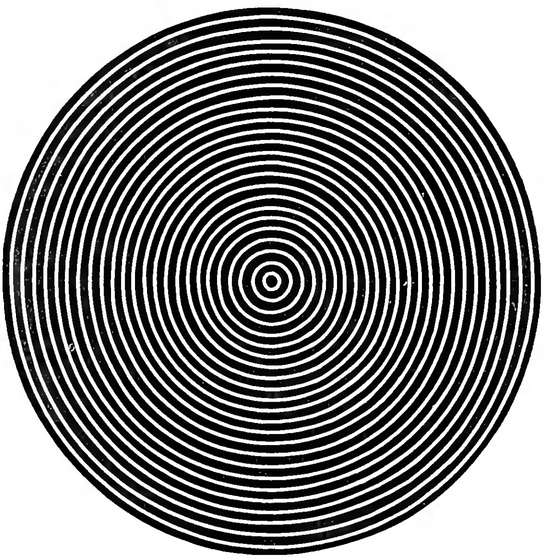
Hence, although optical illusions are of many diverse kinds—illusions of color, illusions of form, illusions of size, illusions of distance, illusions of solidity, and illusions of motion—they have all to be considered from the twofold standpoint, the purely optical and the psychological.

For some months the writer of this article was engaged upon a study of one set of optical illusions, namely, the illusions of *motion*, and a number of observations, collected at intervals over several years, have been added by him to the stock of knowledge previously gleaned by Brewster, Wheatstone, Faraday, Plateau, and others. Brewster made a number of observations, in the early days of railways, on the various illusions which can be found by watching objects from a moving train; Wheatstone investigated a curious case of apparent fluttering motion at the border of two brightly illuminated colored surfaces—due probably to the attempt of the unachromatic eye to obtain fruitlessly a distinct focus of the border-line between the unequally refrangible colors—known as the illusion of the "Fluttering Hearts"; Faraday investigated the illusions produced by intermittent views of moving objects, since developed in the phenakistiscope and zoetrope, and kindred toys, and due to persistence of visual impressions. Brewster, moreover, drew attention to the existence of another class of illusions—illusions of subjective complementary motion—the typical case of which occurs also in railway-traveling. After looking out of the window at the pebbles and other objects lying beside the line, as they pass before the eyes, let the eyes be closed suddenly, when there will at once be perceived an apparent motion in the opposite sense, undistinguishable forms and patches of light seeming to rush past the blank field. This was recorded by Sir David in 1848, and the phenomenon was referred by him to a subjective complementary motion going on simultaneously, and so causing a compensation of the impressions moving over the retina. A kindred phenomenon had been even earlier noted by R. Addams, who, in 1834, narrated how, after looking for some time at a waterfall and then at the water-worn rocks immediately contiguous, he saw the rocky surface as if in motion upward with an apparent velocity equal to that of the descending water. This he ascribed to an unconscious slipping of the inferior and superior recti muscles of the eyeballs, which he thought occurred while watching the falling water, and which he supposed to continue unconsciously after the gaze had been transferred to stationary objects. This explanation differs from the one offered by Brewster, namely, that there was a subjective *opposite* movement going on simultaneously, so causing a compensation of the impressions moving over the retina. Brew-

ster's hypothesis is, indeed, extremely vague, and is neither physical nor psychological in any exact sense. If understood physically, it means that there is actually motion in the retina itself, which is hardly conceivable, since the structure of the rods and cones almost precludes even any idea of vibration, or of propagation of waves of motion by vibration, much less any movements of them as a whole. And, if the explanation is intended as a psychological one, something further is needful before the principle of compensation here laid down could become intelligible.

The first experiments made by the writer of this article upon illusions of motion arose from a casual observation in 1876. He had been preparing, for the purpose of testing astigmatism, a set of concentric circles in black and white, such as those shown in Fig. 1. Happening

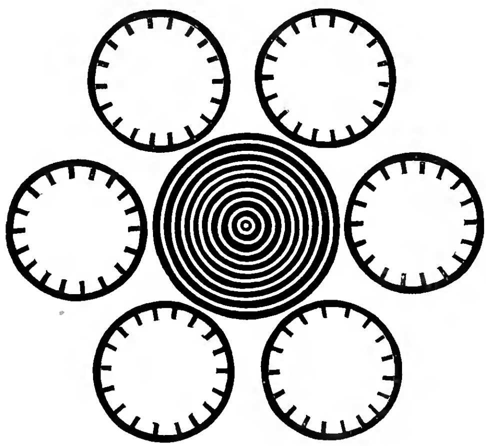
Fig. 1.



to shake the sheet on which the circles were drawn, he noticed an apparent motion of rotation to be set up. The illusion is easily produced by imparting to the pattern a slight motion of the same character as that adopted in *rinsing* out a pail, but with a very minute radius of motion. All the circles will appear to rotate with the same angular velocity as that imparted. Now, undoubtedly the persistence of visual impressions has a good deal to do with the production of this illusion, which, by the way, succeeds best when the circles make from two to four turns in a second, and when the radius of the imparted motion is equal to the thickness of one ring, so that each black or white band is displaced through a distance equal to its own width in all directions successively. Nevertheless, the persistence of visual impressions will

not explain all the facts of this curious illusion: for, in the first place, it is found that for increasing distances from the eye the concentric rings must be made wider if the illusion is to succeed; there being apparently one particular magnitude of their images on the retinæ which favors the production of the illusion. Again, if two such "strobic circles" (as I have called them) are printed side by side on one card, that set of circles seems to turn most effectively at which the eye is *not* looking. On stopping the "rinsing motion" suddenly, there appears to be, for an instant, a reverse motion. Finally, if a set of circles is "rotated" while another set lies motionless within the field of view, the second set will appear to rotate when the first are "rotated" in the manner described above. It is possible, also, to have a number of such apparent motions going on at once independently in one field of view. Fig. 2 shows a compound pattern, containing an

Fig. 2.



interior set of concentric circles and six internally-toothed wheels. When a very minute "rinsing" motion is imparted to this figure, the circles appear to whirl round while the toothed-wheels work slowly backward, moving through one tooth while the circles whirl round once. Here, again, persistence of vision is concerned—but not exclusively.

Dr. Emile Javal, the able director of the Ophthalmological Laboratory of the Sorbonne, has recently advanced an explanation of these illusions different from that adopted by the writer, and in substance identical with that advanced by R. Addams in the case of the waterfall illusion. He avers that the eye, in order to observe a movement, follows the moving body for an instant and then suddenly slips back; that this oscillation, frequently repeated, is associated with a sensation of motion in the particular direction in question; and that when the

eye is subsequently directed to a stationary object it continues the habit of thus oscillating, causing the observer to attribute to the object a velocity of opposite sign to that just observed. M. Javal alleges in support of this view the appearance presented in the ophthalmoscope of the retina of a person affected with *nystagmus*. This affection consists in continual rapid involuntary movements to and fro of the eye. The retina, under these circumstances, appears to be animated with a vibratory motion which M. Javal declares to be identical in character with the apparent movements of the circles. In another place, M. Javal has endeavored to prove that the interior and exterior recti muscles of the eyeball are more prone to this slipping than are the superior and inferior recti, and that these illusions of complementary motion succeed better for motions in an horizontal sense than for vertical and oblique motions. My own experience, and that of other observers, admits of no such conclusion being drawn.

An experiment of Brewster's, which the writer tried without knowing at the time that Brewster had employed it,* has an important bearing on the muscular-slipping theory. A disk marked out into black and white sectors, as in Fig. 3, was caused to rotate at about one revolution per second, so that the separate sensations of black and white were not confused. The eye was steadily directed for twenty or thirty seconds at the central point, and then the gaze was suddenly turned upon some fixed objects, or at a distant landscape. For two

Fig. 3.

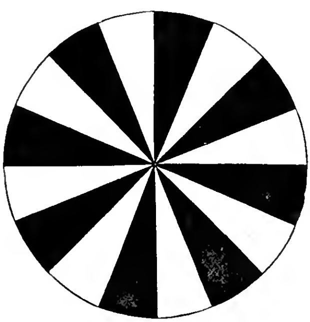


Fig. 4.

or three seconds a hazy rotation is noticed at the center of the field of vision. Now, if the muscular-slipping theory holds good, the complementary movement of rotation must be due to a slipping of the whole of the muscles of the eyeball, and would affect objects all over the field of vision with an equal angular velocity. This is not the case, the apparent complementary rotation being confined to the central field,

* The same experiment was also tried by my friend J. Aitken, Esq., of Darroch, Falkirk, who independently observed the phenomenon described by Addams, and who has also communicated to the Royal Society of Edinburgh a number of experiments on kindred illusions.

and with apparent angular velocities increasing toward the center of vision. Furthermore, I have arranged two such disks so that they could be simultaneously in the field of view while rotating in opposite directions. When the gaze was directed first at a point between them and then at fixed objects, there appeared to be two portions of the field of view rotating, and animated with rotations in opposed senses. Clearly, the eye can not slip round in opposite directions at the same time. In all these illusions, moreover, it is found that this illusory complementary motion only occurs over limited parts of the field of view—namely, those which correspond to the portions of the retina which previously received the moving images. Thus, if a waterfall be looked at—as in Addams's observation—the upward illusory after-motion is confined to a vertical streak across the field of vision. This fact alone is sufficient to negative the theory of muscular slip.

The final test to which I have appealed is, if possible, even more conclusive. It is probably a familiar observation that the end of the last carriage of a retreating railway-train appears to shrink down smaller and smaller as it subtends a decreasing angular magnitude in the field of view. After looking at this motion for a sufficient number of seconds to fatigue the eye, stationary objects appear to be expanding. To produce this illusion more effectually, I take a disk like that shown in Fig. 4 (the figure is quarter actual size), marked out in spirals of white and black. If this is slowly rotated—say at about one revolution in two seconds—the whole pattern appears either to be running into, or running out of, the center of the disk: there is a motion of convergence or divergence, according to the sense of the rotation. Let the disk be turned so as to cause an apparent convergence from all sides to the center, and let the eye steadily watch the center for about a minute, or until the fatigue becomes almost unendurable. Then look at any fixed object—the pattern of the wall-paper, or the dial of a clock—the object so regarded will for some two, or three, or more seconds, appear to be expanding from the center outward. The effect is still more startling if the object thus viewed be the face of a familiar friend. It is quite evident that the eyeball can not slip in all directions at once.

I have, therefore, somewhat reluctantly been led to propound an explanation for these illusions, embodying the theory of them in an empirical law based upon the physical fact of retinal fatigue, and on the psychological fact of association of contrasts. It is as follows: *The retina ceases to perceive as a motion a steady succession of images that pass over a particular region for a sufficient time to induce fatigue; and, on a portion of the retina so affected, the image of a body not in motion appears by contrast to be moving in a complementary direction.* This law is precisely similar to that of the complementary subjective colors seen after fatiguing the retina by the image of a colored body. Similar laws of physico-psychological after-effects are

abundant. A steady sound of one constant pitch ceases to be heard until we become aware of it by its cessation. A steady light of one color, such as the yellow light of gas-flames, ceases to be noticed as a yellow light until some other color-sensation break the illusion. The same is true of smells, of tastes, of the sensations of temperature, of the sensation of rotation after a waltz, and of many others. All these are probably only different instances of the operation of some much more general physico-psychological law. It is quite consonant with these kindred phenomena that, when any region of the retina is affected by an image of objects moving steadily across the corresponding portion of the field of view in any given direction, that portion of the retina gradually loses consciousness of the motion, and perceives it only as a steady sensation, or as one of approximate rest. When, however, an object really at rest is looked at, the associative faculty seizes upon the contrast in the sensations affecting that region, and interprets the new sensation by imputing a motion in the opposite sense to the objects occupying the corresponding portion of the field of vision. I have proposed to give to the empirical law expressing these matters the name of the *law of subjective complementary motion.*

It is impossible to quit the subject without pointing out two lines of thought suggested by that which has been advanced.

Firstly, it is conceivable that the explanation here propounded may at some future time be superseded by a better hypothesis of a more purely physical character. Suppose, for example, that it could be shown—what I have reason to suspect, but have been foiled in all attempts to prove in any experimental fashion—that the eye has the power of altering at will the actual size of the retinal images by a double muscular adjustment between the magnifying power of the lenses of the eye and the distance of their equivalent optical center from the surface of the retina, such a fact, once established, would entirely cut away the significance of my crucial test with the rotating spirals; and the apparent expansions and contractions of objects would be merely due to the continuous attempts of the eye to retain the retinal images of one constant size. If this were so (though I have failed in every kind of attempt to devise some satisfactory test), it might also explain one little matter that is still very mysterious and unexplainable, namely, that in these illusions of expansion and contraction the changes of apparent magnitude often appear to take place by discontinuous jumps rather than by steady motions.

Secondly, it is found that these different illusions affect different individuals with very different degrees of success, some persons being much more sensitive than others to the after-workings of the subjective motion; and, indeed, there are individuals in whose case it is almost impossible to produce the illusions. Doubtless some of these differences may be accounted for by defects of vision, astigmatism, achromatopsy, myopy, and the like. But there is also a time-element in

the case which varies very greatly with individuals, and even varies with the nervous states of the same individual. And this suggests the further thought that a careful comparison of individuals relatively to their illusion-capacity might elicit some interesting and perhaps valuable facts concerning the relation between the states of brain-organization and the sensations of the more highly specialized organs of sense. —*Brain.*

EVOLUTION OF THE CHEMICAL ELEMENTS.*

By LESTER F. WARD, A. M.

MUCH may be said in favor of the hypothesis of the progressive development of all the stable forms of matter by a true process of evolution from antecedent states. Indeed, in the higher forms of matter, in those which we know to be of composite constitution, this process is more or less thoroughly understood. Most of the objects which surround us, whether organic or inorganic, are known to consist of a great number of elementary parts of the same size and form which are aggregated in definite ways to form the general mass which each such object presents. These particles, which are alike for all parts of the same object or species of object, are unlike for different objects. Each object is an aggregate of elements of the same species, and these elements are the *units of aggregation.* All aggregates which have been thus far resolved into these units have confirmed this law. What is known, however, of the higher aggregates of matter is sufficient to establish another law, viz., that such aggregates are the result of the successive recompounding of units of aggregation of descending orders. The units of aggregation of aggregates of the higher orders are compounds of lower units. This is physically proved to be true of all aggregates of known composition.

In biology we have the individuals of various orders, both animal and vegetable, in which the lower forms are taken up bodily and made to enter as integral units into the higher forms. Not only are all animals and plants compounded of innumerable cells as ultimate biological units, but the earlier forms, which are aggregations of cells, are repeated as units in the higher forms. The tape-worm is an animal of the third order, the cell being taken as the first, but its segments are so feebly integrated that they possess all the essential characteristics of perfect animals. In the higher *Annulosa*, the integration is more complete, but the composite character is still evident. In the *Vertebrata*, the process of coördination has proceeded so far that only the

* Read before the Philosophical Society of Washington.

closest embryological study can reveal their composite nature. On the other hand, corals as well as many protists, such as the *Labyrinthuleæ*, coexist with so small a degree of integration that the parts are considered as distinct individuals, although clearly dependent on one another.

The vegetable kingdom illustrates still more clearly the manner in which the aggregates are compounded. We have plants, like *Caulerpa*, which, while the form would lead us to expect a considerable degree of organization, consist in reality of a simple aggregation of homogeneous cells. In higher plants, the leaf forms a new order of organization, and constitutes the morphological individual or unit. In trees, the process of compounding has gone so far that, considered as individuals, they may reach the hundredth degree.

If we contemplate the mineral kingdom, we are again shown the same truth. The various recognized minerals are not generally found to be composed directly of the simple chemical compounds into which they may be resolved, but consist of compounds of different orders into which the simpler compounds enter as units of composition. Thus feldspar contains silica, alumina, peroxide of iron, lime, soda, potash, magnesia, water, etc., as units of composition, none of which is supposed to exist in the mineral in any simpler state, and all of which are already more or less complex chemical compounds. Moreover, two or more of these minerals thus formed often again combine as new units to form others of still higher organization.

When we consider the facts which chemistry furnishes, we see the same law still operating in great simplicity. In many of the binary, ternary, and higher compounds, theory requires us to assume that the substances entering into them do so in their integral state, and are not first decomposed into their primary elements and then reorganized into the new compound. The hydrated oxide of potassium, for example, is not written KH_2O_2, but KO,H_2O, in which both the immediate constituents are regarded as maintaining their composite state and entering bodily into the new compound. The entire series of "compound radicles" requires the same supposition and illustrates the same general principle. Cyanogen (CN), ammonium (NH_4), methyl (CH_3), ethyl (C_2H_5), and the rest are now held to constitute integral units in the formation of the hydrides, alcohols, and acids.

So far, then, as induction can be depended upon, we find that it is a universal law of the aggregation of matter that each new aggregate may become a unit for the formation of aggregates of higher orders. Does this law cease with the so-called chemical elements, or are these themselves the products of molecular aggregation?

Without discussing the old and apparently insolvable problem of the divisibility of matter, it may be remarked that while the known facts of science are entirely satisfied with the hypothesis of an ultimate, finite unit of matter, of which all perceptible objects are but

aggregations, at the same time they do not conflict with such a modification of that hypothesis as assumes the actual magnitude of these units so far reduced as to be practically infinitesimal. They only declare—but this they do in the most emphatic manner—that this reduction must not be so far continued as to make the ultimate atom equal to zero, in the sense of absolute nullity.

On this view, which is by no means a new one, of the ultimate constitution of matter, the units of the so-called chemical elements, even of those having the smallest atomic weights, may themselves be of a relatively high order of aggregation or organization, below which many degrees may exist in which the molecules are too minute to form bodies which the senses can in any manner detect. The interstellar ether may be explained as constituting one of the highest of these degrees, yet not high enough to form matter such as to be visibly subject to the law of gravitation. The nebulæ present the evidence of the lowest form of such so-called "ponderable matter," and these may be supposed to be the result of a gradual development resulting from the successive recompounding of the molecular aggregates, until they finally acquire a certain influence over one another and tend to molar aggregation, forming the nebular masses. At the outset these aggregates may be supposed to be entirely homogeneous, consisting wholly of molecules of the same degree of aggregation, but they soon differentiate into several distinct kinds of matter. These are the gases which the spectroscope reveals in some of the nebulæ. They have molecules of low atomic weights and remain gaseous at all temperatures artificially producible. This process of evolution, which is the same which we have seen to go on in all the well-known forms of matter, would seem also to continue throughout the history of the nebulæ and the organization of resultant planetary systems, developing many additional forms of matter, likewise characterized by the increasing mass of their molecules.

What the properties of those molecular aggregates may be whose activities can not be revealed to sense, is of course unknown. Conjecture even as to the probable number of degrees of aggregation from the ultimate atom to the supposed atom of hydrogen would of course be idle. But that such forms exist far down upon this inaccessible plane, having definite shapes, sizes, and activities, we are strongly led to assume, both by the facts already stated and by others presently to be set forth.

Passing over these lower stages, therefore, whose study belongs to the future of human science, or to possible beings endowed with finer faculties, and which may be said to belong to the domain of transcendental chemistry, we finally arrive at a class of aggregates of great stability, but which, though still so minute that they can only be perceived when accumulated into masses, have nevertheless been studied in their free state by means of the various phenomena to

which they give rise, either in their natural condition, or, as is usually the case, under certain artificial conditions to which the ingenuity of man has learned to subject them. As these aggregates are the lowest which can be perceived, they have been denominated elements, and are by some supposed to constitute the ultimate units of matter. But, independently of certain direct evidence against this view, it is far more consistent with what is now known of matter, and with the laws of thought, to regard them as the first or lowest stages of aggregation whose activities are capable of appealing, either directly or indirectly, to our senses. It is really no more probable that the so-called elements are the lowest subdivisions of matter than that the remotest stars visible are actually at the confines of the universe.

That these elements are capable of manifesting themselves to sense is the sole reason of our recognizing their existence; and the history of their discovery, by which their number has been so greatly increased, shows that their modes of manifestation are often so subtile as to escape all but the most thorough methods of detection. Many of these elements now universally recognized remained for a long time wholly unsuspected, and these then belonged to the great class of unknown aggregates. This interesting chapter in the history of science should suffice to teach us that below the known of to-day there lies a wide belt of the knowable unknown, and that other and still lower orders of aggregates will doubtless yet be induced to reveal their existence.

A reason for regarding these elementary substances as ultimate units has been supposed to be found in their great stability, which causes them to behave as if such were the case.

While there is one possible exception to this in the case of oxygen and the peculiar phenomena of ozone and antozone, it is indeed true, so far as known, of all the remaining elements, that they have thus far resisted all attempts to decompose them. This, however, aside from the possibility of doing so still, is really no evidence of their absolutely elementary character, but only indicates what the whole theory of evolution would admit, if not require, that all aggregates which could possess the properties requisite for the composition of such masses as are capable of affecting the senses, or of so affecting other masses as to make themselves known to the human intellect, must possess a degree of inherent stability sufficient to resist all human efforts to disintegrate them. While, therefore, it is very probable that, just as the alkalies and alkaline earths, which, at the beginning of the present century, were regarded as elementary, have yielded to the galvanic battery and proved to be composite, so a few more of those now classed as elements will at no distant day be similarly decomposed by the higher appliances yet to be devised; it is nevertheless entirely consonant with the view of the constitution of matter here maintained, that there shall remain upon the plane of human investigation a

greater or less number of wholly undecomposable aggregates, serving as the primary basis of all tangible substances.

It must be expected, however, that these elements will possess all degrees of capacity for manifesting their presence, and that while some will stand out boldly, cohere in vast masses, like iron, for example, and in various ways render themselves obvious and obtrusive, others will be ever hugging the confines of the imperceptible, and, like ozone, will perpetually evade the full scrutiny of science. To this latter class also belongs the substance which emits the green ray of the solar spectrum, which has already led eminent chemists to conjecture that it may be of simpler constitution than any recognized element, if not the primary form of matter.

Setting out with the elements, regarded as aggregates of a comparatively high order and stable organization, but differing from one another in form, size, and molecular activities, as widely as the masses they form differ in properties, the problem of the formation of the higher orders of aggregates becomes comparatively simple. We find ourselves already in the domain of experimental science where the more or less completely demonstrated laws of chemistry and molecular physics lead us up to the formation of the various inorganic and organic forms of matter. The constitution of the various substances found upon the earth is readily determined by decomposing them and weighing their constituents. The precise conditions, however, which have resulted in their formation as we find them and brought about the existing state of things in the universe, are not so easily determined, and for this purpose a further extension of the general law of material aggregation is required.

The study of the earth's crust clearly indicates that very different conditions have existed upon it in the remote past from those which we now find. The facts as a whole prove beyond a doubt that our globe has once been in a state both of greater or less liquidity and also of great heat, and that, as its surface has cooled down, the solid parts, to which alone we have access, have been formed, though to what depth these extend we are still ignorant. But, notwithstanding certain doubts which have from time to time been cast upon it, the theory which was very early advanced as most in harmony with the probable history of the planet, and according to which the cooling process has not yet reached the great interior, which is therefore still in a heated and molten condition, still furnishes, perhaps, the most rational explanation yet made of the phenomena which the earth presents, and also best satisfies the *a priori* requirements.

It is now generally believed that the present condition of our earth, and also that of the entire solar system, has been the result of a cosmical process of development by which its matter, unchanged in quantity, has been slowly condensed from a diffused nebulous state, occupying enormously increased space—a condition analogous to, if not

identical with, that which is now presented by a large number of irresolvable nebulæ whose spectra show them to be composed of gaseous matter in an incandescent state. This gaseous or nebulous condition, though exceedingly rare relatively to the solid forms of matter familiar to us, is nevertheless a state of a high degree of aggregation as compared with the forms of matter by which it is surrounded and with its wholly unaggregated state. Before the operations which may be designated as molar can commence, a degree of aggregation must be reached far exceeding that which exists in those molecules which are the vehicles of luminiferous radiations. The particles constituting the ethereal matter of interstellar space must be supposed to be so minute and relatively far separated as not to exert any appreciable influence upon one another tending to produce molar motion or organization ; a condition which is explained on the same grounds as the fact that one system in space exerts no appreciable influence upon another system.

If the so-called chemical elements are simply so many stable molecular aggregates, whose differences are due to different modes and degrees of aggregation, then the gases of our earth are simply the most diffused state in which masses of these aggregates can be obtained. A gas is a diffused mass of homogeneous molecules, and this definition is as true of the compound gases, steam, carbonic acid, or vapor of alcohol, as it is of the simple ones, such as hydrogen, nitrogen, or vapor of mercury. It might, then, be naturally supposed that the nebulæ would contain a number of such gases, and as it is scarcely to be presumed that all the modes of forming stable aggregates are represented on our planet, so, in addition to some of those found here, it is reasonable to expect that nebulæ will contain some not known to us. In so far as the spectroscope—to which, indeed, we owe all our positive evidence of the existence of true nebulæ—is able to inform us, this view is confirmed. Two of our commonest gases, hydrogen and nitrogen, have been identified in nebulæ, while a third has been discovered which has not yet been identified with any known element.

Every modification of the nebular hypothesis yet put forth has been compelled to assume that the original nebulous mass must be in an incandescent state. Certain it is that all visible nebulæ are self-luminous. But this is a condition of their visibility. It can not be known how many may exist which have not yet reached this state, and are, therefore, invisible. It does not seem necessary to suppose that the contraction of a nebulous mass is either due to, or requires, a high temperature. No reason exists why cold particles may not become collected into a diffused mass. The inherent motions of these particles are not increased or diminished. But, these motions remaining the same, their circuits of motion are reduced, the frequency of contact is increased, and heat and light are evolved from the friction. The tendency of all matter under the law of gravitation, considered

as an unexplained fact, is toward concentration. The evolution of heat is rather the check put upon this tendency, and, in so far as it exerts any influence, it exerts it in a direction the reverse of gravitation. There is a perpetual and rhythmic antagonism between the forces of integration and disintegration. When for any reason the former acquires an impetus which carries it to great lengths, it is resisted with increasing violence by the antithetical force evolving great heat, and eventually restoring the normal equilibrium. It seems altogether probable, therefore, that in the process of contraction of a nebulous mass, and its resolution into a system of worlds, the amount of heat radiated is in the end equal to the amount produced by condensation, which disposes entirely of the supposition that there must exist an incandescent nebula at the outset. The so-called "cooling off" is only apparent, and, while at times the amount of heat may be diminished, at other times it will be correspondingly increased. If the radiation of heat from the surface of a body into space tends to cool it off, so does the constant diminution of its volume without loss of mass tend to heat it, and throughout its career these two influences must antagonize each other. It is only after the limit to possible contraction, due to the nature of matter itself, begins to be reached that the amount of radiation of heat comes greatly to exceed the amount of its generation, and that the body actually begins to cool off.

During the greater part of the history of an evolving system, the central mass must possess an enormously high temperature. This is required by chemistry as well as by physics. Throughout nearly the whole of this period, all the matter of the system must exist in the form of gas. But there exist in our globe many substances whose existence in the gaseous state presupposes great heat. The degree of heat required to volatilize the metals is immense, and there are certain other substances, such as silicon, for which still greater temperatures are demanded. It would, however, be a violent assumption to suppose that the parent nebulæ, out of which the solar system was formed, contained from the outset in this diffused state all the substances which are found on the earth. It is much more reasonable, and our hypothesis permits us, to assume that these substances, requiring so great heat to liquefy and volatilize them, have been *created*, i. e., *developed*, during the progress of the formation of the system out of materials already existing in other forms and states of aggregation. On the supposition that during the earlier part, and perhaps during all but the very latest period, of this process the temperature of the nascent system was increasing, it is reasonable to assume that the intense heat would cause the breaking up of some of the molecular aggregates which were capable of maintaining the gaseous form at low temperatures, and would at the same time cause the formation of new aggregates only capable of maintaining that form under the high temperatures to which they were subjected at the time of their for-

mation, many of which, nevertheless, would prove sufficiently stable to preserve the new form of aggregation after the temperature should go down, and, instead of reverting to their former condition on the cooling of the system, would assume successively the liquid and the solid states, and become constituent parts of and distinct substances in the cooled-off planets.

This theory of the origin of all those elementary terrestrial substances which require great heat to convert them into gas is supported by some facts. In the first place, none of the gases of these substances have been discovered in any of the nebulæ. The only two terrestrial substances, thus far determined with any certainty, are hydrogen and nitrogen. The latter of these exists in a free state in the earth's atmosphere, forming about four fifths of its volume and three fourths of its weight. The former does not exist in a free state in the atmosphere, in consequence of its strong affinity for oxygen, which is present there in excess, and whose union with it forms the waters of the globe. Both of these substances are gases at all temperatures producible by artificial means, and have only very recently been made to assume the liquid and solid states by the use of extraordinary devices. The other definite line which the spectrum of certain nebulæ presents is near to that of barium, but is conceded not to be the barium-line. It is, therefore, an unknown substance, and nothing can be said of its properties. Its proximity to the barium-line in the spectrum can not certainly be taken to indicate any special resemblance to that metal; and it is probably a gas at low temperatures, like hydrogen and nitrogen.

In the second place, as to these two last-named substances, one of them, hydrogen, is present in nearly or quite all the self-luminous bodies whose spectra have been observed, where it seems to occupy a position far out in the upper atmosphere. As to nitrogen, its presence in such bodies is doubtful, so far as the spectroscope is able to inform us; but, as it exists in such quantities in the earth's atmosphere, the belief is strong, especially among those who accept the nebular hypothesis, that the failure to discover it there is due to our imperfect methods, or to our ignorance of the manner in which the phenomena of the spectroscope are to be interpreted. The recent triumph of science, in the discovery of oxygen in the sun, serves to show how easy it is to overlook phenomena all the while perceptible, and gives great hope that not only nitrogen, but many other substances, will yet be found there, which have hitherto escaped observation. The fact that an element exists in the earth may not be proof that it must exist in the sun, even on the assumption that the sun is the parent of all the planets, but it is certainly strong presumptive evidence that it is also there. It is, however, much stronger proof that it existed in the general mass, as late at least as when the earth was formed out of it, and therefore in the original nebulæ. Those

evolutionists alone who are ready to accept the view here advanced of the derivation of the heavier elements from the lighter ones, in the course of the development of the system, can escape this conclusion by supposing that the substance in question was created in the planet after its separation from the central mass. But this assumption would not be required in the case of nitrogen, which remains a gas at high temperatures, and which actually exists in the nebulæ. The fact that it can be detected in the nebulæ, and not in the sun, although it doubtless abounds in both, may be accounted for by remembering that the spectrum of a nebula belongs to a different class from that of the sun, the former consisting of bright lines on a dark ground, indicating a luminous gas ; while the latter consists of dark lines on a bright ground, indicating a body having an incandescent solid or liquid interior, the rays of which pass through a cooler gaseous atmosphere. Now, this antithesis in the constitution of the two bodies may explain why certain elements existing in both may be capable of spectroscopic determination only in one, owing to peculiar conditions supplied by the special nature of the substances themselves ; for it is by no means probable that the spectroscope gives us an account of all the substances existing in the bodies examined by it.

While, therefore, there is nothing in the facts thus far discovered which is opposed to the theory that the terrestrial substances having high melting and volatilizing points have been developed out of substances which are gaseous at lower temperatures in the course of the evolution of planetary systems, these facts, so far as they bear at all upon the problem, are decidedly favorable to such an hypothesis. We certainly find such substances in our earth and in the intensely heated bodies of space, as well as in such meteoric aggregates as from time to time reach our planet, and we have not yet found any such in existing nebulæ. If the latter be conceived as gaseous, and the solar system as only a developed state of one of them, either some such hypothesis must be brought forward to explain the existence of such substances in the earth, or the original mass must be supposed to possess a sufficient degree of heat to maintain them in a gaseous form, which would be enormous, and, independently of the present theory of the origin of the nebulæ, altogether improbable. Of course, upon the view here taken, it would be wholly inadmissible. Prior to the stage in the history of a nebula at which the degree of molar aggregation is sufficient to occasion a great amount of friction among the particles, the temperature of the primary molecular aggregates must be nearly that of space, and it can rise only as increase of density and molar motion increases that friction and converts material motion into ethereal vibration. Nebulæ must therefore possess a long history, of which neither the telescope nor the spectroscope can furnish any record—the pre-luminous period—in which, of course, no gases can exist except those, like hydrogen and nitrogen, which maintain their gaseous form

under extremely low temperature. And it may be supposed that during this period other gases may exist associated with these, which, however, unlike them, are unable to sustain the successively higher and higher temperatures which the nebula acquires in its process of condensation and organization into a system, and at certain stages of this process are dissociated and resolved into aggregates of a different constitution, suited to these temperatures. Some of these latter new aggregates would naturally assume the liquid and solid forms at temperatures still high as compared with those to which we are accustomed, and constitute in the cooled-off crust of the planets the various metals and metalloids. In this manner we should have no difficulty in accounting for the existence of all the elements found on the earth, even if it were positively known that only the lighter gases were present in the parent nebulæ.

The recognized elementary substances, presenting so many different qualities, vary greatly in their so-called "atomic weights." This means simply that their molecules vary greatly in mass. The hydrogen molecule is the least known, and is therefore taken as the standard. Compared with this as unity, we find that the molecule of oxygen contains 16 times as much matter, that of carbon contains 12, that of nitrogen 14, and that of chlorine $35\frac{1}{2}$ times as much. But these, instead of representing large equivalents, are, when compared with most of the metals, very small. One molecule of mercury contains two hundred times as much matter as one of hydrogen. The atomic weight of gold is 197, of platinum 197·4, of lead 207, and of bismuth 208; while the thorium equivalent, which was quadrupled in the new system, is now put at 231·4, being the largest of all the elementary units. Whether hydrogen, carbon, nitrogen, oxygen, or any of the other abundant elements having small molecules have entered into the composition of these heavy substances, is a legitimate question. The fact that these molecules are stable, whether combined or uncombined, is favorable to this view, although there may exist, as component units of the molecules of the metals, many equally stable aggregates which no human power can dissociate from their present combinations. But, if known elements were employed as components of other known elements having larger molecules, the very fact that they are elements, i. e., that we are unable to decompose them, would render it impossible to know that such was the case. Think how many hydrogen, nitrogen, or oxygen molecules might enter into the system that constitutes the unit of bismuth or of gold!

Now, it is a remarkable fact that those elements which have very high condensing points, i. e., which assume the liquid (or solid) form at very high temperatures, generally have large combining numbers, that is, large molecules; while those having low condensing points and which are gaseous at ordinary temperatures, as a rule have small combining numbers, or small molecules. To this, carbon on the one hand,

and mercury on the other, form, it is true, notable exceptions; nevertheless, the bulk of the facts sustain this law, and indicate that the genesis of those elements which we know only as solids or liquids, and which we have supposed to have taken place during the fiery ordeal through which the solar system has had to pass, is rather a process of *integration* than of subdivision, since they have much larger molecules than the gases that exist in the nebulæ, and out of which we have supposed them to be formed.

We have seen that matter, in its cosmical history, as enacted in the development of a planetary system, assumes a great variety of forms, and resolves itself into numerous specifically distinct molecular aggregates. The different substances which we know on our planet are the result of the cohesion into homogeneous masses of these different aggregates, all the constituent units of any one of these masses consisting of the same *species* of molecular aggregate. We saw reason to suppose that, at an early period in the development of the solar system (and we may infer the same for all systems), the number of distinct substances was small, and that these substances were gaseous at very low temperatures. The two abundant gases, nitrogen and hydrogen, exist in the irresolvable gaseous nebulæ, and these, doubtless, went far to constitute the original substance of our infant system. These gases, though differing greatly from each other in their atomic weights, nevertheless have small molecules compared with those of most substances now found in the earth, and which are, for the most part, either solid or liquid at life-supporting temperatures. There has, therefore, been upon the whole *increase of mass* among the molecules of substances later developed.

When we rise to the point of view which removes all distinction between elements and compounds, except the subjective one that in the former we do not know and can not prove their composition, while in the latter we can do this in so far as to resolve them into the former, we can make the further generalization that along with this increase of mass there has gone *decrease of stability* in such molecules. We are of course unable to predicate this, except inferentially, of the elements which we can not decompose, although these, doubtless, vary greatly in their relative stability, and, as before remarked, some substances which had been supposed to be elementary have already been reduced to simpler forms, and others may still be so reduced. Moreover, those which have thus yielded possess large molecules (counting that of the compound), and this should serve as an index to future attempts of a like nature. There is, for example, little hope of resolving hydrogen or carbon into simpler elements, but the reverse of the alchemist's dream may yet be realized, and gold reduced, if not to baser, at least to simpler materials.

All the known chemical compounds must be supposed to have been

developed within relatively quite recent periods. The great heat that has prevailed throughout the greater part of the history of the solar system, and which, indeed, still prevails in its nucleus, the sun, which is still $99\frac{13}{15}$ (99·866) per cent. of the entire mass of the system, or practically the whole of it, has prevented the formation of any of the substances which we know to be composite. It is only in the comparatively minute masses which have been accidentally separated from the rest, and which, in consequence of their diminutive size, have earlier reached the point at which the radiation exceeds the generation of heat, that conditions have been produced under which these comparatively unstable substances, such as water, carbonic dioxide, and the other oxides comprising the earth's crust, could exist. In proportion as the degree of heat diminished, the capacity for more and more unstable substances increased. The earliest compounds were those in which silicon, potassium, sodium, magnesium, etc., combine with oxygen, several of which were, from their great stability, long regarded as elementary. Then came a variety of acids, alkalies, and salts, together with compounds of the metals. Later, as the temperature still further lowered, the oxygen was enabled to seize the hydrogen and form the gaseous protoxide, steam, which at a still later period, when the temperature of the earth's surface fell below 100° Centigrade, condensed into water. Long prior to this, carbonic acid had been formed, and, doubtless, constituted at that time fully one half of the earth's atmosphere. The vast amount of free carbon now existing in the earth, and, still more, that which is fixed in the chalk and limestone formations, all of which must have formerly existed in the atmosphere in the form of carbonic-acid gas, indicates that the above estimate is probably far too low.

All the compounds thus far referred to, and all others having a certain degree of stability, must have been first formed at a period of considerable heat, the dissociation point of all compounds having been estimated at 6,000° Centigrade; although this, doubtless, varies for different compounds as greatly as do the condensing points of different gases. But there are, besides, many compounds which are continually forming at such temperatures as now prevail on the surface of the earth, and most of these are very much more unstable than those last mentioned. The elements which chiefly enter into such compounds are oxygen, nitrogen, hydrogen, and carbon, all but the last named of which are gaseous at ordinary temperatures. The substances of this nature with which we are familiar are known as *organic compounds*, and such as we see are, in fact, the products of organized beings from the different parts of which they are obtained. But this process should not be regarded as any less cosmical than that by which the rocks or the metals have been evolved out of primordial matter.

Time forbids the further following out of this series of steps in the development of existing forms of matter, but it will be readily per-

ceived how, if this train of reasoning be sound, the inorganic is directly linked to the organic world, just as the imperceptible forms of matter were shown to be linked to its perceptible forms, and the elementary states to the composite states, in one continuous and unbroken chain. It remains to point out to what extent the hypothesis here advanced, of the probable genesis of the chemical elements, is found to be in harmony with the recent discoveries which Mr. J. Norman Lockyer has made by means of the spectroscope in the domain of chemistry. In endeavoring to do this in the briefest manner possible, let us reproduce the following diagram drawn up by him :

$$\left.\begin{array}{l}\text{Hottest stars,}\\ \text{Sun,}\\ \text{Cooler stars,}\end{array}\right\}\text{Lines of}\left\{\begin{array}{l} \mathrm{H} + \mathrm{Ca} + \mathrm{Mg} \\ \mathrm{H} + \mathrm{Ca} + \mathrm{Mg} + \mathrm{Na} + \mathrm{Fe} \\ — \quad — \quad \mathrm{Mg} + \mathrm{Na} + \mathrm{Fe} + \mathrm{Bi} + \mathrm{Hg}.\end{array}\right.$$

$$\begin{array}{ll}\text{Coolest,} & \text{Fluted bands of} — \quad — \quad — \quad — \quad — \quad —, \quad \text{etc.}\end{array}$$

Modified in the arrangement only to suit the present discussion, the first part of this diagram may be presented as follows :

$$\overbrace{\overbrace{\overbrace{\overset{1}{\underset{1}{\mathrm{H}}} + \overset{24}{\underset{12}{\mathrm{Mg}}} + \overset{40}{\underset{20}{\mathrm{Ca}}}}^{\text{Hottest stars.}} + \overset{23}{\underset{23}{\mathrm{Na}}} + \overset{56}{\underset{28}{\mathrm{Fe}}}}^{\text{Sun.}} + \overset{200}{\underset{100}{\mathrm{Hg}}} + \overset{208}{\underset{208}{\mathrm{Bi}}}}^{\text{Cooler stars.}}$$

The figures placed over the symbols are the respective atomic weights of the elements according to the new system, those placed beneath being the same according to the old system. Transposing calcium and magnesium merely for the sake of symmetry, their position being indifferent, since both appear in the hottest stars, we find that with a single exception, that of sodium, if we take the new system, and without exception, if we take the old system, the atomic weights increase as the temperature of the body diminishes. To what extent this result may be accidental it is of course impossible to say, but, so far as it may have any scientific significance, it constitutes an interesting confirmation of the theory that the heavier elements with large molecules have been developed out of the lighter ones with small molecules during the progress of the condensation and refrigeration of the heavenly bodies, and according to which, as above pointed out, those possessing the largest equivalents would be last formed and gradually pass into the known compounds by a corresponding gradual decrease of stability, these latter to be succeeded in turn by the evolution of organic aggregates which ushered in the era of life.

Generalizing from all that has been said, we may divide the known

forms of matter into the three following classes, with the accompanying definitions :

1. Chemical Elements.—Substances whose molecules are composed either of those of other chemical elements of less atomic weight, or of such as are too low to be capable of molar aggregation, and therefore imperceptible to sense : formed during the progress of development of star-systems at temperatures higher than can be artificially produced, and hence too stable to be artificially dissociated.

2. Inorganic Compounds.—Substances whose molecules are composed of those of chemical elements or of other inorganic compounds of lower degrees of aggregation : formed in the later stages of the development of planets at high but artificially producible temperatures, and therefore capable of artificial decomposition ; and constituting the greater part of the solid crust of cooled-off bodies, their liquid and a portion of their gaseous envelope.

3. Organic Compounds.—Substances whose highly complex and very unstable molecules are composed of those of chemical elements, inorganic compounds, or organic compounds of lower organization : formed on the cooled surfaces of fully developed planets at life-supporting temperatures.

ONLY A VINE-SLIP.

By T. G. APPLETON.

THE world's life is one long day, in which events strike the hours. The hours strike, time moves on, till another stroke marks an advance which could only be that of the present moment, and to which all the minutes of the past have contributed. I seemed to hear that clock of the ages strike, the other day at my table, when a charming young Frenchman was explaining why he had come to America. It is humiliating to man, haughty in his mastery of this world, to find a successful antagonist, the least of creatures, microscopically small, and nameless often, till the baffled husbandman is obliged to write it in Greek or Latin characters upon the banner of his conquering foe. The *Phylloxera* is mightier than a German army ; for the latter, once satiated, goes home, but the former apparently stays for ever. The Egyptians are again upon us ; the plagues of Egypt, and perhaps, what is worse, the plagues of America, move across the world, devastating as they go. The contagion of evil seems to outrun that of beneficence in an unfair proportion. Creatures unconscious of what they do, which the microscope barely discovers, terrify whole nations, and give the lie to the arrogance of man. Somewhat as the old thought is now super-

seded, the old faith of the mind sapped, by the maggot in the brain which breeds doubt and, denial, so in these latter days, the old beldam Earth breeds *oïdium* which blights, the phylloxera which destroys. It was the phylloxera which interested my young Frenchman. He had just come from California, after sending home countless *boutures* (vine-slips) to his father, a *vigneron* of Burgundy. It is found that these bits of vine, planted in France and then grafted with the vine of the district, will resist in most cases the phylloxera, and so save the vineyard. It was when hearing this from my young *vigneron* that I seemed to hear that earth-clock strike. The sound I thought was braided of two murmurs where joy and sorrow blended. "Yes," I said to myself, "youth is a good thing, and how beautiful it is to see it sustaining the decrepitude of age!" How proud, thought I, should America be to see her democratic blood mingled with to sustain the princely lives which Bacchus honors! American girls wear the strawberry-leaf and sit not far from the throne itself. And how like this is the marriage between the *parvenus* of California and those princely ones whose *etiquette* gleams at royal boards! But how are the mighty fallen! The imperial house of Clos Vougeot is in the dust, and many another lordly house besides. A friend of mine, an expert in the science of wine, crowned his wealth by the purchase of this imperial Clos (field) of Vougeot. This little field, the most precious for its extent in France, a true Field of the Cloth of Gold, whose grape is the highest expression of God's beneficence through the vine he gave us, has a flavor, perfumed, modest, tasting of the violet, which separates it from the crude and harsher vintages as a gentleman is distinguished among roughs. This favorite of the earth, this consummate flower of France, Providence shall not long allow to lie perishing in the dust. And it is the democrat who shall fly to the rescue of this scion of an imperial house. For the world of epicures will not be deprived of its dainties; and it is no more than justice that America should heal the wound she makes, for it is confidently asserted that vines from America, imported into the south of France, brought the phylloxera with them. But this is only guess-work; there is a mystery in the modern sudden distribution over the world of insects and weeds which is not understood. It can not be watched, because it is not suspected, and secretes itself as part of a freight fetched for quite another purpose. Mrs. S. C. Hall has told us how, for ten years before, the weed *Anacharis alsanastrum* spread with frightful rapidity over the inland waters of England, choking ponds and rivers, as may be seen in the Serpentine of London, the germs of which plant were supposed to have been secreted in imported timber. I have recently, however, read that this plant was dying out, apparently finding its environment unsatisfactory. It is interesting also to hear of a process, the reverse somewhat of California's grape-cure, namely, how the robust weeds of England devour, as Britons do the natives, the weaker weeds of Australia. So have we

devoured and displaced the Indians ; and some think the plucky English sparrow, after whipping all birds of its weight, is destined in the future to take their place. The law which permits such strange invasions of foreign seeds and insects is evidently not a demand for them in a place where they strike. It is no part of a scheme of use or beneficence ; they are a law unto themselves, and attach where they can find a foothold. They ravage as a fire does where the air or the earth is ready to flame like tinder, and they challenge man, as yet victoriously, to match his newly acquired knowledge, his microscope, and his chemistry, with the vivacity of their attack. The renowned M. Pasteur vainly fights for his silk-worm, nor is the battle yet decided ; soon all the resources of science, all the skill of the naturalist, will be needed to beat back the invading armies. Man has made, in so much, Nature his slave. He bridges the ocean, he pierces the Appian barrier, he trains the lightning to fetch and carry for him, he pierces stellar space, he analyzes the sun, and, when he feels an obstacle, he forces his way ; neither the sands of Suez nor the marshes of Panama delay him ; but he stands baffled before his invisible enemy. A breath of air can poison his cities, or devastate his harvests. Nature thus comes back with an unexpected boomerang. *Entre nous, deux maintenant.* And, though proud man clearly anticipates his final triumph, cholera and yellow fever come and go at their own sweet will. The Colorado beetle journeys comfortably to visit foreign parts. A new plague of locusts, the grasshopper of the West, leaves famine behind him as he moves, and even the Gascon wine, into which the nose of Thackeray once dipped, feels an unholy presence, the blight of a new disease.

But there are other things which fly on the wings of the wind besides the seed-capsule which nourishes, the flower-germ which ornaments ; thought also goes with them as they fly. Never was it so volatile, not as once hoarded in some vast brain, packed into folios by the weary hand, buried in the silence of cloisters through long ages, and at last fructifying suddenly in a thousand lives. Thought now is ever active, omnipresent ; an idea now germinates in San Francisco, and a week later is stale in India. The solidest creeds get their edges frittered away by these clouds of passing thought. Custom secures a little the stability of things, but much of it is automatic—the heart is gone out of it. The monarchist is often a better democrat than his American brother, the priest who intones his service is tampering with agnostic infidelities, the Arab sheik presents you with his photograph, and the King of Siam adds a lift to his palace. There is hardly such a thing as discussion ; assertion usurps the hour, and there is no reply. Everybody could be on either side of the questions which once distracted the world ; and as we see the Prince of Wales over a cigar, trifling with democratic notions, the old noble humbled before the feudality he represents, the priest meshed in a network of hypocrisies

from which he would gladly escape—when we see these things, are we not reminded of the phylloxera which can taint the goblet in the hand of a king, of the secret foe which silently saps the health of cities, and that confusion of life and death, which, flying upon the wings of the wind, affronts the stablest security and makes a jest of human conservatism?

THE METEORS OF NOVEMBER 13TH-15TH.

By Professor DANIEL KIRKWOOD.

WHEN the coincidence between the orbits of the November meteors and the comet of 1866 was first clearly established a few years since, it was supposed by astronomers that the so-called Leonids formed a single cluster, diffused through an arc of such length as to require three or four years to make its perihelion passage. The meteoric period was shown by Professor Newton, of Yale College, and J. C. Adams, of Cambridge University, to be thirty-three and one fourth years. Consequently, no further displays were expected from this stream till about the close of the century. But in "Nature" for June 3, 1875, numerous facts were given, all indicating the existence of a second group, less dense in its structure, and preceding the principal swarm by twelve or thirteen years. Again, the large number of meteors seen in 1879, taken in connection with the fact that, according to Humboldt, meteors were seen in unusual abundance just thirty-three years before, viz., in 1846, suggested the probable existence of a third and perhaps still smaller cluster, passing its perihelion about 1879-'80. It was felt to be important, therefore, that in case any considerable number of meteors should be visible this year at the November epoch, the shower should be observed and the facts recorded. Accordingly, I requested Professor D. E. Hunter, Principal of the Washington (Indiana) High School, to keep watch on the mornings of November 13th, 14th, and 15th. Professor Hunter has made a comprehensive report, which I have somewhat abridged in the following statement. The morning of the 13th was cloudy, and on the 15th the moon shone brightly till daybreak. The watch was consequently restricted to the morning of the 14th. Four observers were occupied from $3^h\ 45^m$ to $5^h\ 45^m$—precisely two hours. The position was on a hill south of Washington, where the view was unobstructed, except on the south. One hundred and sixteen meteors were counted, ninety-one of which were conformable to the radiant in Leo. During the first hour the atmosphere was hazy and the moon interfered with the observations. The second hour was clear and moonless. The following table includes only Leonids, giving the number counted in every five minutes:

3h. 45m.	to	3h. 50m.,	1	meteor.		4h. 45m.	to	4h. 50m.,	3	meteors.
3 50	"	3 55	1	"		4 50	"	4 55	6	"
3 55	"	4 0	0	"		4 55	"	5 0	6	"
4 0	"	4 5	0	"		5 0	"	5 5	7	"
4 5	"	4 10	0	"		5 5	"	5 10	1	"
4 10	"	4 15	0	"		5 10	"	5 15	2	"
4 15	"	4 20	0	"		5 15	"	5 20	7	"
4 20	"	4 25	5	"		5 20	"	5 25	7	"
4 25	"	4 30	0	"		5 25	"	5 30	12	"
4 30	"	4 35	4	"		5 30	"	5 35	11	"
4 35	"	4 40	0	"		5 35	"	5 40	5	"
4 40	"	4 45	4	"		5 40	"	5 45	9	"

Table showing the same Meteors as above by the Quarter-Hour, Half-Hour, and Hour.

3h. 45m. to 4h. 0m.,	2	2	15	Moon during first hour.	4h. 45m. to 5h. 0m.,	15	25	76	No moon second hour.
4 0 " 4 15	0				5 0 " 5 15	10			
4 15 " 4 30	5	13			5 15 " 5 30	26	51		
4 30 " 4 45	8				5 30 " 5 45	25			

REMARKS.—1. The maximum was at $5^h\ 30^m$, when five Leonids were seen in one minute.

2. The shortest path—two degrees—was that of a meteor nearly stationary, seen in Leo at $5^h\ 18^m$. The longest—forty degrees—crossed Ursa Major at $5^h\ 20^m$.

3. The average length of path during the first hour was six degrees ; in the second, about seven ; the increase being probably due to the absence of moonlight.

4. At least three distinct meteoric swarms move in the track of Tempel's comet (1866 I.). One has just passed or is passing perihelion ; the second will pass about 1887–'88 ; and the maximum group about the close of the century.

5. The meteors on the morning of the 14th inst. were more numerous than those of the August shower ; a fact quite remarkable when it is remembered that it is fourteen years since the great display of the principal cluster.

6. The estimated periods of the comet and the meteor groups of the Leonid ring are as follows :

Tempel's comet	33·176 years.
Group A	33·250 "
Group B	33·333 "
Group C	33·500 "

The last is derived from the showers of 1813, 1846, 1847, 1879, and 1880.

7. Oppolzer's period of Tempel's comet, as given above, is perhaps too short. If this body was a return of the comet of 1866, its mean period is 33·283 years—very nearly the same as the meteoric periods.

8. It is sufficiently obvious that we have yet much to learn in regard to the constitution of the Leonid ring, and that future observations from the 13th to the 15th of November may probably result in important discoveries.

BLOOMINGTON, INDIANA, *November* 25, 1880.

PREHISTORIC SCIENCE EN FÊTE.

TO the uninitiated an "International Congress of Prehistoric Anthropology and Archæology" may seem a formidable affair, where no more cheerful entertainment than a feast of dry bones could be allowed, and where a member indulging in a joke would be instantly called to order. Those who attended the late meeting of this Congress at Lisbon know better. They know that under cover of their imposing title this scientific Congress can give itself up to sociability, and even levity, without imperiling its dignity. They know that this assembly of men, representing the scientific world in nearly every country in Europe, has as human an idea of enjoyment as the most ordinary mortals who have never even heard of the Neanderthal skull, and to whom the term palæolithic or quaternary man calls up no vision of cave-bears or hairy mammoths, living hob-and-nob, so to speak, with our flint-using ancestors.

Let us follow the fortunes of the Congress, the idea that the typical Dryasdust flourishes among its members being dispelled. The first unofficial *séance* may be said to have taken place at Almorchon, a junction half-way from Madrid, where all the scientific pilgrims, more or less tired and dusty, made a rush at the buffet to get what food was to be had. Those who had been traveling from Madrid since the previous evening and those who had taken a preliminary tour through Andalusia here met, and instantly there was a Babel of tongues—German, Italian, French, and English. Only Spanish was not to be heard, so that, but for the tropical heat of the sun and the Sahara-like aspect of the surrounding country, one would hardly have realized that one was in the Peninsula. Friends were inquiring how each other's work had sped since the meeting four years ago at Buda-Pesth, or that of Stockholm two years earlier. Scientific men who had never met before, and who only knew each other by books or letters, were being "enchanted to make each other's acquaintance" in the best French they could muster. Some were deploring in hushed tones the great loss just sustained by anthropology in the death of M. Paul Broca, who was to have been present at Lisbon. Here was the universal favorite, M. de Quatrefages, of the French Institute, in a gray suit and wideawake, looking more like a genial English geologist than a French *savant*,

shaking hands with all. Professor Virchow, talking slowly to a learned *confrère* on the one hand, and M. Henri Martin, deep in an Iberian controversy, on the other. Here was a spruce and speckless Frenchman, as fresh and bright as in his native Paris; there, a crumpled German, bearing evident traces of a night in the train. After all, there was ample time to exchange greetings and compliments, as well as for the more important business of eating, as the proverb, "Hurry no man's cattle," is also applied to trains in Spain. A Spaniard in a hurry was the one curiosity no member of the Congress was fortunate enough to light on, although every facility to see all the rarities of the country was politely accorded them.

At last the excruciating sound of the whistle summoned all to ensconce themselves in their snug corners of the carriages again, and only at daybreak next morning—on Sunday, September 19th, to be exact—did this first detachment of science, coated with a yet thicker layer of dust, arrive at Lisbon, after thirty-three long hours from Madrid.

Until last year a direct train accomplished this journey in ten hours less time; but Spain, tenacious of old traditions, suppressed that train as savoring too much of progress, and consequent Nihilism and dynamite.

All that Sunday the newly-arrived foreigners talked of nothing but the lovely position of Lisbon, with its many hills and broad Tagus. They much admired the great reservoir of the famous aqueduct with its tail sixteen miles long, and also the cats with no tails at all. Lisbon literally swarms with cats, and not a few have their ears and tails cropped; this is a scientific note made by a *savant* on the spot. There were also many speculations among this festive company as to whether they should get as much dancing as at Pesth, where—let not this confidential disclosure damage their scientific reputation—in the course of one short week did they not fit in three dances, one of which was extemporized in the waiting-room of a railway-station, in returning from a ghoul-like expedition, undertaken for the purpose of rifling some dozen Bronze-age graves? Such was their heartless levity! After this disclosure it will be no shock to hear that, on the eve of their serious work at Lisbon, most of this frivolous body patronized the bull-fight. In extenuation, it must be admitted that a Portuguese bull-fight is not, like the Spanish, a public shambles and knacker's yard, but a bloodless trial of dexterity, from which the gorgeous cavaliers, on their splendid Andalusian horses, come out unharmed; and the bull, whose horns are encased in leather-and-iron gloves, is driven out very happily among a herd of tame oxen, whose business—and well the sagacious animals understand it—is to decoy him out of the arena.

The following day there was the impressive inauguration of the Congress by the King himself. The hall provided for the *séances* is the library of a suppressed monastery, where all the old calf and vel-

lum bound books lining the walls seemed quite in harmony with the dryness of some of the discussions, though the way our authorized ancestor Adam was unanimously ignored might have made the worthy old monks' hair stand on end. At one end of this hall a great throne was erected, with ermine and the Braganza arms all complete. Opposite a band was stationed; in the gallery around admiring natives were congregated. All the male representatives of science were in evening dress, *gibus* in hand, and resplendent with orders. M. Capellini, of Bologna, a great man though small of stature, was noticeable for the number of his decorations. With four full-blown crosses and ribbons, besides a dozen lesser stars glittering on his shirt-front, he was a gorgeous sight. The only English member yet arrived was conspicuous for the unrelieved black and white of his attire.

With royal punctuality, precisely at one o'clock, the band struck up the national hymn, and their Majesties entered: Dom Fernando, the tall Dowager King Consort (if that is his official title), and Dom Luis, the dumpy reigning King, his son. Every one, it is to be hoped, knows Thackeray's "Rose and the Ring," and if they do not they should know it, so it is needless to describe their royal highnesses further than by saying that the courteous Dom Fernando is the image of the old king in that charming tale, and the accomplished Dom Luis its hero Prince Bulbo in person. There was no mistaking the fact, the immortal Bulbo stood before us—on tiptoe mostly, to add height to his august presence—and we were duly impressed accordingly. With royal patience he and his father sat under their ermine awning, listening to inaudible speeches, with *homme miocène* as their refrain—what a long course of boring it must take to teach any one to bear it so patiently! who would choose to wear a crown?—and then with royal courtesy they descended from their eminence to be introduced to the leading members present. That over, they had to begin again with the Literary Congress, whose session here also opened that day; while the archæologists and anthropologists escaped to examine the bony and stony treasures of a museum illustrating these sciences, established in the same building. In this arid region many warm discussions as to the antiquity of man took place, and as to how far some undetermined flakes of flint, with dubious bulbs of percussion, found in a questionable stratum, went to prove his existence in Tertiary times. This was the main question of the Lisbon session.

Two days afterward an excursion was made to Otta, the above-mentioned haunt of this doubtful Tertiary being, to test the value of the evidence. By 6 A. M. all on science or amusement bent were steaming out of Lisbon. An hour later all had left the special train, and were distributed among twenty-two carriages and omnibuses, drawn, as a rule, by four fine mules, the manners and customs of which were curious and unexpected. The leaders would suddenly bolt round and stare at their scientific load with superhuman curiosity. It re-

quired many of these wayward beasts to drag the carriages through the four or five inches of dust underfoot. After three hours of such wading, a little sheltered from the blazing sun by the clouds of dust the mules raised, Otta was reached. Otta, or rather a sandy wild with a thin growth of foot-high dwarf-oaks, some miles farther on, is the spot our Tertiary phantom is supposed to have selected for his dwelling. There was a lake there in those days. No one would be predisposed to acknowledge as an ancestor either man or ape capable of displaying such bad taste in his choice of a home; for in Portugal beautiful and wooded retreats abound, so there was no excuse for settling in a bare desert—except perhaps the fishing. However, all dutifully hunted for this creature's remains; but only one flake, near the surface, was found by an Italian, Signor Belucci from Rome, and that caused hardly less excitement than the discovery of a new gold-mine.

But the dryness of the day and subject was exhausting, even to those most affected by the *fièvre tertiaire*, and all readily abandoned the dust of ages and flocked into a tent, a lodge in that vast wilderness, which seemed to have come there by enchantment. Due justice was done to the sumptuous breakfast prepared, for science does not impair the appetite, and then followed endless toasts. The health of the foreign members having been proposed, a representative of each nation, French, German, English, Italian, Spanish, Danish, Swedish, and Slav, returned thanks in widely varying accents for their hospitable reception in Portugal. M. de Quatrefages was by far the best orator, and the President, Senhor João d'Andrade Corvo, spoke well. After much time, wine, and breath had been expended, a practical Englishman, who meant work, and was not broken in to foreign dilatoriness, proposed as a final toast *Au silence et au travail.* The hint was taken, and hammers and sunshades again put in requisition, but again with no decisive result. Two of the ladies of the party, escorted by two gallant Frenchmen, made the difficult ascent of a neighboring steep hill, to look down disdainfully on the worthy archæologists grubbing below like ants, and following as useless a quest as those minute busybodies seem to indulge in as a rule. When it is mentioned that the thermometer stood at 96°, it would be superfluous to indicate the nationality of the fair climbers.

But for an opportune vineyard passed on the return journey, all Europe might have been bereaved of her science, as the great expedition nearly died of thirst. Anthropology would have been nipped in the bud, and archæology would have returned to the dust, had not a supply of grapes averted the awful calamity.

Next morning, Wednesday, primeval cannibalism was the subject of debate, but "long pig" was not discussed for dinner, as might have been expected, thanks to good Portuguese cookery.

The day following the gay assembly were abroad again, going to Santarem, where they were received with flags and rockets, welcomed

by the mayor, and escorted to the kjökkenmöddings, their goal, by hundreds of picturesque mounted peasants. Here a grand display of skeletons, and of the refuse of the meals by which these frames were nourished, rejoiced their eyes; and later the speechifying, etc., were gone through with as much enjoyment as before.

On Saturday the two kings honored the *séance* with their presence to hear the great Tertiary debate, which M. Mortillet, of the Musée St. Germain, opened with needlessly elementary instruction as to the formation of flakes, and asserted his belief in the disputed ancestor's existence in a speech lasting an hour and a half.

> "He argued high, he argued low,
> He also argued round about him."

An Englishman, known, from his habitual demand for evidence, in the foreign scientific world as *le petit St. Thomas*, answered him with geological and other objections. He said that no flakes indubitably found in these Tertiary beds were of unmistakable human manufacture, but were such as might be due to natural forces; and insisted on the necessity of strong proof before accepting, as an established fact, man's existence at a time so widely remote from ours—a time when the hipparion was the nearest living representative of the horse, and since which the whole fauna had almost completely changed. Then St. Thomas wound up by declaring that, though for twenty years he had upheld the antiquity of our race, as proved by the discoveries at St. Acheul and in other old river-valleys, and it therefore ill became him to dispute it now, he could not be satisfied to rest his pedigree on a single bulb of percussion.

M. de Quatrefages, who does not believe in evolution as applied to the human race, declared for Miocene man. So did M. Capellini, who had already brought some pet whalebones, found in the marine beds of Italy, before the Congress at Pesth; which bones he believes to have been scored in Miocene days by wrought flints. Others venture to think the marks may be due to the teeth of fishes rather than to human agency. Virchow was dubious. Most suspended their verdict until there should be more conclusive evidence, so the resolution of this great question was adjourned to the next session.

Of course, one excursion was to lovely Cintra, and to Dom Fernando's picturesque Penha palace perched on a peak there, with its castellated walls and little gilt domes. It was grand to see *savants* gravely riding the tiny donkeys down perilously deep descents. However, thanks more to the sure-footedness of the beasts than to the skill of the riders, no one came to grief. The views at Cintra over the rocky peaks, great pine-woods, and long-stretching plain, with the misty Atlantic as an horizon, are beautiful, and the Moorish remains there are most curious. That evening the real King gave a ball at Cascaes to the Congress, but, in spite of the courtesy of the hosts, the dancing

was less gay than at Pesth, not being *impromptu*. The supper was the great feature of the entertainment. Footmen in gorgeous liveries brought in trays of tempting delicacies, fish, flesh, fowl, and good red wine, to which all were prepared to do justice after a hard day's work. Only there were no plates, knives, forks, or other appliances of civilization. Nothing but large wooden toothpicks.

All hang back, eying longingly the dainties good manners forbade them to seize, and watching what course royalty would pursue.

But the court, nay, royalty itself, unhesitatingly took a toothpick, dug it into the chosen morsel, poised it a moment in the air, and it was gone. Thus emboldened, all possessed themselves of these handy instruments, and dug in their turn, roving and sipping like bees, though all with inward misgivings as to whether they had been spirited away suddenly to China or some other Eastern haunt of the primitive chopsticks. On after-inquiry it was learned that in all large court assemblies these toothpicks were put in requisition, as it was feared that silver forks might be pocketed by the guests. It was neither as an insult to scientific honesty, nor a compliment paid to the archælogical tastes of the Congress, that such primeval weapons were used.

The day after this last and most foreign experience nearly all these learned birds of passage had flown—some to the wintry north, others to the sunny south, all bearing a grateful remembrance of a charming week, and of the warmth of Portuguese hospitality; all speculating as to when and where would be their next merry meeting.—*Fraser's Magazine.*

SKETCH OF COUNT POURTALES.

BY the death of this able naturalist, in the full maturity of his powers, American science has sustained a great and irreparable loss. We give a likeness of him from the only photograph we could find, and, as no biography of him, that we are aware of, has been written, we are indebted for the materials of this statement to such fragmentary notices as have been furnished to the press since his death.

Louis François de Pourtales was of the Swiss nationality, and was born in 1823. He belonged to an old family, which had branches also in France, Prussia, and Bohemia. He was educated as an engineer, but showed from boyhood a predilection for natural history. He became a student of Professor Agassiz, and was one of his favorites, accompanying him to America in 1847, and joining in his early labors, first at East Boston, and subsequently at Cambridge. In 1848 he entered the Government service in the department of the Coast Survey, and continued in it many years. Professor Theodore Lyman, writing of Pourtales in the "Boston Advertiser," says:

"His talents and industry made him a man of mark, to whom was intrusted much work that required original thought. Especially did he show interest in the problems of deep-sea soundings and the structure of the ocean-bottom, an interest that led to profound observations on the physical geography of the Caribbean Sea and the Gulf Stream. His papers on this subject were of the first order, and established his reputation in Europe as well as in America.

"By the death of his father, he succeeded to the title, and received a fortune which enabled him to devote himself wholly to his favorite studies, and to do much in continuing the great work of Louis Agassiz. Appointed keeper of the Museum of Comparative Zoölogy, he gave himself, with untiring devotion, to carrying out the arrangement so laboriously planned by his friend and master. Dividing the task with the curator, Alexander Agassiz, he pushed forward his part of the work with the easy power of a strong and highly-trained intellect. Every day and all day at his post—now pursuing special investigations, and now directing the details of the museum—he was the model of an administrative officer.

"He had not an enemy, and could not have had one; for, although firm and persevering in temper, he possessed the gentleness of a child and a woman's kindness. His modesty amounted almost to a fault; and people wondered why a man who was master of three languages should talk so little. But with intimate friends he would speak freely, and never without giving information and amusement. His range of learning was very wide, and his command of it perfect; nor was it confined to mathematics, physics, and zoölogy. He did not scorn novels and light poetry, and was knowing in family anecdotes and local history. Indeed, it was a saying in the Museum that, if Count Pourtales did not know a thing, it was useless to ask any one else."

Professor Alexander Agassiz writes to "Nature" as follows: "M. Pourtales was the pioneer of deep-sea dredging in America, and he lived long enough to see that these expeditions had paved the way not only for similar English, French, and Scandinavian researches, but had led in this country to the Hassler, and finally to the Blake Expeditions, under the auspices of the Hon. Carlile P. Patterson, the present Superintendent of our Coast Survey. On the Hassler Expedition from Massachusetts through the Straits of Magellan to California, he had entire charge of the dredging operations; owing to circumstances beyond his control, the deep-sea explorations of that expedition were not so successful as he anticipated.

"The materials of the different deep-sea dredging expeditions above mentioned had been chiefly deposited at the Museum in Cambridge, and were thence distributed to specialists in this country and in Europe. A large part of the special reports upon them have already appeared. M. Pourtales reserved to himself the Corals, Halcyonarians, Holothu-

rians, and Crinoids. A number of his papers on the deep-sea corals of Florida, of the Caribbean Sea, and of the Gulf of Mexico, have appeared in the Museum publications. He had begun to work at the magnificent collection of Halcyonarians made by the Blake in the Caribbean Sea, and had already made good progress with his final report on the Holothurians. The Crinoid memoirs published by him relate to a few new species of Comatula and to the interesting genera Rhizocrinus and Holopus.

"The titles of his memoirs indicate the range of his learning and his untiring industry. His devotion to science was boundless. A model worker, so quiet that his enthusiasm was known only to those who watched his steadfast labor, he toiled on year after year without a thought of self, wholly engrossed in his search after truth. He never entered into a single scientific controversy, nor ever asserted or defended his claims to discoveries of his own which had escaped attention. But, while modest to a fault and absolutely careless of his own position, he could rebuke in a peculiarly effective, though always courteous, manner ignorant pretensions or an assumption of infallibility.

"Appointed keeper of the Museum of Comparative Zoölogy after the death of Professor Agassiz, he devoted a large part of his time to the administration of the Museum affairs. Always at his post, he passed from his original investigations to practical details, carrying out plans which he had himself helped to initiate for the growth of the institution. As he had been the devoted friend of Professor Agassiz's father, he became to his son a wise and affectionate counselor, without whose help in the last ten years the Museum could not have taken the place it now occupies. If he did not live to see the realization of his scientific hopes, he lived at least long enough to feel that their fulfillment is only a matter of time. He has followed Wyman and Agassiz, and like them has left his fairest monument in the work he has accomplished and the example he leaves to his successors."

H. N. Mosely communicates to the same journal the following observations on Pourtales's scientific work: "Almost from the commencement of his connection with the United States Coast Survey he deeply interested himself in deep-sea questions, and some of the earliest observations on the nature of the deep-sea bottom and of Globigerina mud were made by him. He wrote on the structure of Globigerina and Orbulina, and described the occurrence of the small Globigerina-like shells bearing spines in the interior of certain Orbulinæ, which he concluded were the swollen terminal chambers of Globigerinæ containing young in progress of development. The first step in deep-sea investigation in the United States was taken by the late Professor Bache on his assuming the duties of the United States Coast Survey in 1844, when he ordered the preservation of specimens brought up by the lead. Every specimen was carefully preserved and labeled,

and deposited in the Coast-Survey Office in Washington. The microscopical examination of the specimens was commenced by the late Professor J. W. Bailey, and after his death this work passed into the hands of Pourtales, who devoted his time to it in the intervals of other duties. That most important deposit, Globigerina mud, was first discovered by Lieutenants Craven and Maffit, U. S. N., during Gulf-Stream explorations in 1853. In 1867 systematic dredging in deep and shallow water was commenced on the assumption of the superintendence of the Survey by Professor B. Peirce, who ordered the dredging. At the suggestion of Louis Agassiz, dredgings were made down to a depth of one thousand fathoms. In Professor Agassiz's report, one of the richest grounds for deep-sea corals, lying off Cape Florida, was named Pourtales Plateau. In 1871 Pourtales published what is probably his best-known work, namely, his "Deep-Sea Corals" ("Illustrated Catalogue, Museum of Comparative Zoölogy," Harvard, No. iv), a most excellent memoir containing valuable disquisitions on the affinities of various genera, and excellent notes on the geographical distribution of the species and the nature of the bottom on which the dredgings were made.

"Count Pourtales's name is indissolubly connected with deep-sea zoölogy by means of the genus Pourtalesia, named after him. Pourtalesia, a sea-urchin, one of the Spatangidæ allied to Ananchytes, was found by the Challenger Expedition to be one of the most ubiquitous and characteristic deep-sea animals. Numerous species of the genus new to science were obtained by the expedition in deep water, some of them being of most extraordinary shapes. In conclusion, it need only be added that Count Pourtales's kindness and good-nature were as much appreciated by English naturalists as elsewhere. He was most generous, always ready to give advice to naturalists working in the same most difficult field as himself, to supply them with specimens for investigation, and to discuss in the freest manner, with perfect impartiality, any question of systematic arrangement. He will be regretted by many friends in England, to which he paid frequent visits on his way to his native country, his last visit having been made in the spring of the present year."

Count Pourtales was a man of a strong frame, a vigorous constitution, and a temperate mode of life, which gave hope of a long period of usefulness. But he was attacked by a fatal internal disease, and, after several weeks of great suffering, heroically endured, he died at Beverly Farm, in Massachusetts, on July 17, 1880, aged fifty-seven years.

EDITOR'S TABLE.

THE FORCES OF HUMAN PROGRESS.

THE interesting volume of Mr. Henry George, on "Progress and Poverty," was discussed in the "Monthly" upon its first appearance, though rather for the purpose of making it known than of criticising it. But, as it has now become a success, and passed to a fourth and cheaper edition, it becomes desirable to look more closely into some of its positions. It is not, however, the author's doctrine of the great and growing evils of land monopoly, nor the remedy which he proposes for these evils, nor the economic views he has put forth, that now concern us. The first nine books of his treatise are devoted to these topics, but in the tenth and concluding book he takes up another and a larger subject. He here discusses "the law of human progress," and opens the weighty question of the philosophy of all social and political reform; and with the views here advocated we can not at all agree.

The argument of Book X, though not strictly a part of the main thesis of the volume, grows naturally out of it. Having traced certain great social evils to their root, and shown, as he believes, how they may be escaped, he was of course urgent that his measure should be forthwith adopted, and the good it promises secured. Impelled to write his book by realizing the squalid misery of a great city, which appalled and tormented him, he was driven by the whole force of his sympathies to find some plan of removing it, and when found he was naturally eager that it should be applied. But he was here confronted by the school of thinkers which now teaches that genuine and permanent social ameliorations must be far more gradual in their operation than has formerly been supposed; that the progress of human society is but part of a larger and very deliberate progress in the course of nature, and which takes place through the agency of natural laws to a great extent independent of the volitions or intentions of men. They teach that man himself is a product of progress, and has been so developed and transformed by nature that he at last begins to be capable of understanding nature's method, and of consciously taking part in the progressive work.

Mr. George takes issue with this whole theory, and coolly rules nature out of the entire business. He denies "that human progress is by a slow race development." He says, "We have seen that human progress is not by altering the nature of men," and again, "Human progress is not the improvement of human nature."

He further denies "that progress is by hereditary transmission," and affirms "that human will is the great factor." The view to which he holds is thus briefly intimated: "Mental power is, therefore, the motor of progress, and men tend to advance in proportion to the mental power expended in progression—the mental power which is devoted to the extension of knowledge, the improvement of methods, and the betterment of social conditions. Now, mental power is a fixed quantity—that is to say, there is a limit to the work a man can do with his mind, as there is to the work he can do with his body; therefore, the mental power which can be devoted to progress is only what is left after what is required for non-progressive purposes. . . .

"These non-progressive purposes in which mental power is consumed may be classified as maintenance and conflict. By maintenance, I mean not only

the support of existence, but the keeping up of the social condition and the holding of advances already gained. By conflict, I mean not merely warfare and preparation for warfare, but all expenditure of mental power in seeking the gratification of desire at the expense of others and in resistance to such aggression. . . .

"Association in equality is the law of progress. Association frees mental power, for expenditure in improvement and equality (or justice or freedom, for the terms here signify the same thing, the recognition of the moral law) prevents the dissipation of this power in fruitless struggles. Here is the law of progress which will explain all diversities, all advances, all halts, and retrogressions."

Nothing can be more unsatisfactory than this. It sounds like last-century talk, before science had entered upon the investigation, and ignores a whole continent of facts that have been upheaved during the last two or three generations, and which are fundamental to any theory of human advancement. These scientific revelations force upon us the question of the improvement of man in his earlier stages, as an indispensable key to the understanding of his later advancement. Mr. George says, "Whether man was or was not gradually developed from an animal, it is not necessary to inquire." That depends entirely upon the thoroughness of the inquiry it is proposed to make. Is it so obvious that the progress of man has nothing to do with the development of man? Surely knowledge is preferable to ignorance in regard to man's early history, as well as most other things. It is not all the same, for the purposes of truth, what theory we adopt of man's mode of origin. If the universe was jerked into existence out of nothing and altogether, some six thousand years ago, and if the first man came along with it perfected in intelligence, and endowed with a language suitable for the purposes of a comprehensive zoölogical nomenclature, then, indeed, all inquiry respecting the emergence of man is unnecessary. But this childish theory of his first appearance was long since exploded, and the growth of modern knowledge compels the adoption of another. Mr. George says, "We know that there have been geological conditions under which human life was impossible on this earth"; and he here tacitly gives away his whole case, for the implication is of a great historic order in nature, of the antiquity of the earth, and of the course of life as a time-problem of vast import. The indubitable records of life go back millions of years, perhaps millions of ages, in terrestrial history. And this life not only had its progress, but its incontestable mental progress. There was a slow and gradual passage from the lower to the higher, with successive epochs of advancing intelligence, the creatures nearest to man in organization coming last before man himself appeared.

We have here the conception of progress deep in the constitution of Nature. We have her method, which is that of progress by the operation of natural law. There was a time when the human race did not exist upon the earth, although it had been for countless ages a theatre of developing life. Will Mr. George maintain that man did not come in conformity with the preëxisting order? Does he deny that man is a part of Nature, the sequel of an organic series, and to be studied and interpreted in the light of the great unfolding law of this series? All the facts show not only that man has had a much greater antiquity upon this earth than was formerly supposed, but that he had a very low beginning. There was a prehistoric and primitive man, who dwelt in caves, made and used implements of stone, lived by hunting, and was the lowest kind of a savage. So much is established, whatever be the worth of speculations regarding his derivation from an

inferior animal. The civilized man of to-day is the descendant of this ancient and semi-brutal savage; and the problem of human progress involves an elucidation of the laws by which human nature has been developed and transformed, so that the creature that could not count his fingers may yet count a Newton among his descendants.

It is obvious that Mr. George's theory of progress can not in the least explain the earlier stages of social development. The cave-men did not say "Go to, let us progress," but they blindly struggled with their circumstances, and out of these struggles came improvement. Their experience was of conflict with wild beasts, which they had to kill in self-defense and to get the means of subsistence. For this purpose, the brutal and aggressive passions required to be strong. The life was predatory, and the aboriginal savage was cruel, revengeful, and delighted in the infliction of pain. How could such a creature, with his unsympathetic and unsocial nature, be brought into even the rudest forms of society? Only by a coercion so stern that it could subjugate his refractory passions, and force him into some kind of coöperation.

Mr. George is unable to see how war and slavery could ever have aided improvement, progress, and freedom. He quotes as absurd the reasons given for this view, namely, Comte's idea that "the institution of slavery destroyed cannibalism," and that "slavery began civilization by giving slave-owners leisure for improvement." But these are by no means the reasons on which this view rests. The question is, how brutal men were first subjugated and learned the lessons of subordination, which are the first steps of social progress. A coarse and inexorable discipline was required, such as befitted the natures to be subdued. War and slavery were just those relentless agencies that could force savages to work together, and habituate them to that respect for power which was an indispensable condition of the lowest forms of social order. The strongest man became the chief and the despot. Tyranny was indispensable. Where the moral condition of men was evinced by the habitual practice of cruelty, the wanton destruction of life, the torture of prisoners, cannibalism, and human sacrifices, the restraining power had to be inexorable and ferocious. It was by the arbitrary discipline of war that men first learned obedience; and, as the chief became king and government a military despotism, there gradually grew a stability in social relations and a progress of social institutions. War was an education in obedience, but not the sole education. Slavery was the result of war. Prisoners not killed were reduced to bondage. Despotic coercion was thus systematized, and the benefits of war were thus gained in time of peace. With his unsubdued nature, the habit of submission and of continuous application could only be acquired by the aboriginal man through a long apprenticeship of painful enslavement.

Recoil as we may at these contemplations, there is no evading the fact that this is Nature's method of human progress, and accordingly as we value the result must we appreciate the means that brought it about. That war may now hinder the beneficent work which it formerly promoted, is undeniable; but we are not to forget the part it has played when we undertake to explain the conditions and causes of human progress. What is all history but a bloody record of War's and Slavery's violence and injustice? Men are greatly changed and greatly improved, but civilization is still barbarian. Hostility looking to war is the international norm. We have plenty of survivals from our savage ancestors. Animals that they hunted from necessity, we hunt for sport; the gratification of killing continues. War is a regnant profession, the pastime of Christendom;

and slavery disappeared from among us but yesterday. And how did it go? As a behest of the humanity of the nation? As a victory of philanthropy, education, Christianity, and the higher forces of progress? No! it was not removed by the national volition, but it went out in a convulsion of domestic carnage.

Obviously there is a great deal to be done yet before man will be prepared to take the work of human progress out of the hands of Nature, and carry it on in his own wiser way. He can do much; but the first thing he has to learn is that he can not do everything, and to find out what is practicable of accomplishment. He can not realize his dreams, and can only embody a small part of his aspirations. By his pre-scientific and unscientific education, he is not imbued with the method of Nature, and is too unconscious of the difficulties and impediments in the way of attaining his sanguine hopes. Dwelling, in virtue of his predominant culture, in an ideal world that he constructs to suit himself; taught by novelists, dramatists, and poets, whose function it is to create imaginary worlds; familiar with religious doctrines which teach the facile convertibility of human nature; studying history which is ever occupied with human doings, and ever exaggerates the offices of great men; and surrounded by a world filled with suffering and injustice—men come to think that all this evil might be quickly done away with if there were only the disposition and the will. As Mr. Bagehot somewhere says, only a short time ago it was the common belief that, if everybody would set to work in good earnest, human society might be renovated and perfected and brought to a millennial condition in about ten years. Science, as it confers a deeper knowledge of the order of the world, sobers our judgment and dissipates these pleasing illusions. Let it not be said that science thus becomes obstructive, and paralyzes exertion; on the contrary, it is promotive of real progress by checking futile effort, and disclosing the conditions and the way by which exertion may be made most effectual and substantial conquests achieved. And, in these times that are so prolific of social Utopias, no teaching is more valuable or more wholesome.

MONDAY-LECTURESHIP PHILOSOPHY.

In the absence of Rev. Joseph Cook, the work of the Boston Monday lectureship has gone on by the aid of other clerical talent. The course was opened December 6th by Bishop Clark, of Rhode Island, who gave an address on "The Seen and the Unseen," of which an authentic version was published in the "Boston Traveler."

The Bishop succeeded well in adapting himself to the new circumstances. He entered easily into the general line of speculation for which this lectureship has become renowned, and filled the shoes of its Rev. Founder to a nicety. Whether it was the effect of association, or blue-Monday, or what, the speaker glided into the peculiar habits of the place, and indulged in logical licenses which could have been no novelties to his auditors. The Bishop discussed the problems of matter and spirit, the connection between the body and the soul, and the problem of personal immortality; and he here opened the question of the relation of religion and science in so explicit a way that readers on our side can not fail to be interested.

After an elaborate preliminary argument, he says: "The bearing of all this upon the question of our own personal immortality gives to the subject a most profound and solemn interest. It is hardly conceivable that man should have been endowed with immortality, and yet so constituted as to be unable to arrive at any satisfactory proof of the fact. To those who receive the records of the

New Testament as authentic and true, no further demonstration is needed." And yet a little further on this important position is very materially qualified. The Bishop points out that the Scriptural presentation of the doctrine of immortality is neither made prominent nor emphatic, and, notwithstanding "its profound and solemn interest," he gives reasons why it was best to leave it meager and obscure. He uses the following language: "The light that is thrown upon the next stage of existence in the Scriptures is designedly somewhat general and limited. All the direct information on the subject which they give could be condensed into a very small space. The eschatology of the Old Testament could all be written on a single page, and very much in the New Testament which has been supposed to relate to the subject is now referred to the setting up of the kingdom of truth and righteousness here on earth. 'The kingdom to come' in many cases means simply the kingdom of Christ among men. Revelation was not intended to gratify our curiosity, and it would not be well to make the veil which hangs between us and the future too translucent. Our work is here, and, if that work is properly done, we can afford to wait until an actual entrance into the next world reveals its mysteries. The time is not most properly employed which is spent in speculating about these mysteries."

This is rational and encouraging, and a wide departure from the traditions; for theology has always maintained that the universe is insufficient for man, even during the short time that he occupies it; and that the knowledge of his immortal future is a thousandfold more momentous to man than all he can learn about the present world. In liberal contrast to this, the Bishop now assures us that the teachings of revelation upon this subject are general and limited; that it was not intended merely to gratify our curiosity; that it would not be well to remove the veil that hides the distant future; that our work is here; that we can afford to wait; and that speculation about those mysteries is not the most profitable.

But, having indulged in this little episode of common sense, the Bishop seems to have remembered where he was, and quickly tacked back into the middle current of the Monday lectureship. There is no more talk of unprofitable speculations, and veils not to be rent. The secret of this transcendental mystery of spiritual existence *must* be plucked out, and it must agree with the calculations about it, or life is a cheat and all nature an empty mockery! This view is enforced with rhetorical emphasis in the following spirited passage:

"A division as old as Aristotle separates speculators into two great classes—those who study the How of the universe, and those who study the Why. All men of science are embraced in the former of these, all men of religion in the latter." I would like to under stand both, if this is possible; but, if I must choose between the two, I would rather know the reason for which I exist than the mode by which I exist. The one is an end, the other only a means. If it is impossible to discover the end, or if that end, when it is supposed to be discovered, does not seem to be such as justifies the elaborate process by which it is reached; if all the magnificent discoveries of science land us in the conclusion that the universe is only a great clock put together and weighted and wound up to run for a certain period, and then when it has struck the last hour to fall to pieces and become resolved into the materials of which it was originally made—the clock having marked the process of time faithfully and truly as long as the flow of events continued, but the time itself leaving behind no permanent results which abide after the clock has ceased to strike—if the end of existence is exhausted in the process by which that existence is registered, and terminates with the process; or, again, if the universe is only a huge electric wheel throwing out sparks of life which glisten for an instant in the darkness and vanish for ever; or, again, if man is only the effervescence of a physical compound that buds and blossoms and then dies as soon as the soil furnishes no further sustenance—

why, then the universe is a sham and man an impertinence. All comes to nothing in the end, consciousness ceases when the phosphorus in the brain ceases to burn, and with the end of consciousness the material world might as well shrivel and die and come to nothing also.

This is a significant enunciation, and will bear pondering. We have seen no clearer statement of the respective attitudes of the theological mind and of the scientific mind toward the things of this world. What is the value of the great scheme we call nature taken at what we know of it? Margaret Fuller, neither theologian nor scientist, but fond of the mystical, offered, on the whole, to "accept" this universe. Bishop Clark, not to be taken in by shams, will accept it conditionally, that is, if he has assurance that its end is such as to justify the process by which it is reached. The universe has no worth in itself, and can only acquire it as it is found to conform to the theological standard—a standard, moreover, which was set up in ages of ignorauce before anything had been found out concerning the nature, character, method, or magnitude of the object valued. Here the universe is, a mighty, boundless, unfathomed fact; if it squares with the theological ideal of what ought to be its design—an ideal framed without any knowledge of its constitution—it may be approved; otherwise, it is a humbug, and, the sooner it shrivels into nothingness, the better.

It is to be here noted that on either theological alternative science is suffocated. Theologians claim to have long known the grand why and wherefore of this universe, but that never inspired them to inquire into its how—never led to science. For, having the greater explanation already, why should they concern themselves about lesser explanations? The greater explanation not only superseded the lesser, but condemned them. Familiar with the futurities, and having in hand the lever that controls the beatitudes and the torments of an immortal destiny, it would have been recreancy for the theologians to favor trivial inquiries into what was doomed soon to "pass away as a scroll." They were logically bound to resist all tendencies to such trifling in this probationary world. So, the men who knew the why proscribed, imprisoned, strangled, and roasted the men of vain curiosity who strove to understand the frivolous how. There was, therefore, plenty of consistency in the orthodox antagonism to the spread of the spirit of science.

But if, on the other hand, the why can not be known as the theologians claim to know it, independent of all knowledge of the how, then on the authority of Bishop Clark the universe is a sham, and who is going to get up much interest in the study of shams? A man will not seriously inquire into that for which he has no respect; and, just to the degree in which people are imbued with this spirit of contemptuous indifference for the present world, will be their carelessness in relation to that scientific truth which raises the value of life in proportion as it is known and applied.

And which is the most reverent and the most truly religious attitude—not to raise any question of humility—that which assumes to pronounce on the aims and purposes of the universe, while contentedly ignorant of all truth regarding its order, or that which searches out its wonderful constitution, that it may rise to its plans and purposes, as gathered from its beautiful structures, its exquisite harmonies, its beneficent adaptations, and the solemn grandeur of its mighty movements? We protest against the doctrines which the Bishop offers us in the name of religion, as well as much else that emanates from the platform where he spoke. And we would respectfully suggest to the devotees of the Monday lectureship, if it would not have been

better to avail themselves of the absence of St. Joseph to get a few lessons in religious liberality by holding "deacon meetin's" and listening to the reading of "Scotch Sermons."

LITERARY NOTICES.

Scotch Sermons, 1880. New York: D. Appleton & Co. Pp. 345. Price, $1.25.

This book is a surprise, and as gratifying as it is unexpected. Its title is anything but inviting. Of all branches of literature sermons are generally and justly pronounced the dullest, and of the class of sermons, everybody would expect to find the Scotch the driest. This is what sharpened surprise and produced actual astonishment when we looked into this unpromising volume. We have been accustomed to regard Scotch Presbyterianism as the narrowest and most intolerant and intractable form of Calvinistic orthodoxy, which would be the very last to yield to the liberalizing tendencies of the time, but we have been much mistaken. The mechanical law that action and reaction are equal and opposite seems to hold rigorously in the theological sphere, so that the counter-impulse now displayed in the Scottish Church is, perhaps, more vigorous, comprehensive, and fruitful than is to be found in any other religious body.

This volume, dedicated to Dean Stanley, consists of twenty-three sermons, preached by various men, located in various places, and all clergymen of the Church of Scotland. Its editorship is anonymous, but its editor declares that it "has originated in the wish to gather together a few specimens of a style of teaching which increasingly prevails among the clergy of the Scottish Church. It does not claim to represent either the full extent of that teaching or the range of subjects on which, in their public ministrations, its authors are in the habit of discoursing. It may, however, serve to indicate a growing tendency and to show the direction in which thought is moving. It is the work of those whose hope for the future lies not in alterations of ecclesiastical organization, but in a profounder apprehension of the essential ideas of Christianity; and especially in the growth within the Church of such a method of presenting them as shall show that they are equally adapted to the needs of humanity and in harmony with the results of critical and scientific research."

There is, of course, considerable inequality in these productions, coming as they do from such diverse sources, but they are all of a superior character, and there are a unity and a harmony in the views advanced which show that the liberalizing movement in the Scottish Church is broad, consistent, well defined, and well matured. The writers treat their respective topics independently, but with a remarkable concurrence of opinion, which shows that the more expanded views are the result less of any effort at agreement than of an unconscious growth of rational conviction.

But these sermons are not less remarkable for their free and catholic spirit and advanced principles than for the intellectual power which various of them evince in dealing with the present phases of religious thought. They are not the mere impatient protests of men chafing under the influence of an outworn system, but they are philosophical in temper, constructive and conservative in tendency, and evince a masterly grasp of the questions that are now tasking the best minds of the age. There is no timidity, no panic about imperiled faiths, and the old errors are repudiated with decision, but without harshness or bitterness. It is ably shown how religion is the gainer by being freed from the false beliefs that have been so long associated with it, and so widely mistaken for it.

These sermons are, moreover, remarkably free from that jealous antagonism to Science which in these days characterizes so much of our mediocre literature of theology. Science is neither fiercely denounced as leading to materialism, nor coldly complimented and left to go her ways. Her results are cordially accepted as a great revelation of truth, and of truth which is also of the highest religious importance. Instead of shrinking with horror at the scientific doctrine of development as something which threatens to sweep away all religion, these clear-sighted men recognize that this doctrine is at the basis of religion itself.

They understand that all stereotyped faiths and fixed creeds are doomed to be left behind, while the spirit that animated them must assume new forms under a widened and advancing religious experience. It is certainly a most remarkable result that out of the Scottish Church, in 1880, should come this weighty proclamation to the religious world, that the great law of continuity and evolution, as unfolded and established by modern science, is to become a foundation and bulwark of religious faith in the future. "He that hath ears to hear, let him hear."

We should be glad to reprint half these sermons in the "Monthly," but, as this is impossible, we give a few passages illustrative of the standpoint of the book. The Very Rev. John Caird, Principal of the University of Glasgow, has the first discourse, on "Corporate Immortality," which is an able plea for interest in "The things of this life" as opposed to the overshadowing claims of another world. He says:

It needs little reflection to perceive that the whole order of things in which we live is constructed not on the principle that we are sent into this world merely to prepare for another, or that the paramount aim and effort of every man should be to make ready for death and an unknown existence beyond the grave. On the contrary, in our own nature and in the system of things to which we belong, everything seems to be devised on the principle that our interest in the world and human affairs is not to terminate at death. It is not, as false moralists would have us believe, a mere illusion, a proof only of the folly and vanity of man that we do not and can not feel and act as if we were to have no concern with this world the moment we quit it. It is not a mere irrational impulse that moves us, when, in the acquisition of knowledge, in the labors of the statesman and legislator, in the houses we build, the trees we plant, the books we write, the works of art we create, the schemes of social amelioration we devise, the educational institutions we organize and improve, we act otherwise than we should do if our interest in all earthly affairs were in a few brief years to come to an end. It is not due to a universal mistake that we work for a thousand ends, the accomplishment of which we shall not live to see; that the passions we feel are more intense, the efforts we put forth immeasurably greater, than if we were soon and for ever to have done with it all. Even the desire of posthumous fame, which has been the theme of a thousand sarcasms and satirical moralizings, the passion that impels us to do deeds and create works which men will be thinking of and honoring when we are gone, does not rest on a mere trick of false association, which your clever psychologist can explain so deftly, but is the silent, ineradicable testimony of our nature to the share we have in the undying life of humanity.

Does any one press on me the thought that, say what you will of the future, death to each of us is near, and no ulterior hope can quell the nearer anxiety as to what is to become of us, and how we are to prepare for that fast-approaching, inevitable hour? Then, I answer finally that, to whatever world death introduce you, the best conceivable preparation for it is to labor for the highest good of the world in which you live. Be the change which death brings what it may, he who has spent his life in trying to make this world better can never be unprepared for another. If heaven is for the pure and holy, if that which makes men good is that which best qualifies for heaven, what better discipline in goodness can we conceive for a human spirit, what more calculated to elicit and develop its highest affections and energies, than to live and labor for our brother's welfare? To find our deepest joy, not in the delights of sense, nor in the gratification of personal ambition, nor even in the serene pursuits of culture and science, nay, not even in seeking the safety of our own souls, but in striving for the highest good of those who are dear to our Father in heaven, and the moral and spiritual redemption of that world for which the Son of God lived and died—say, can a nobler school of goodness be discovered than this? Where shall love and sympathy and beneficence find ampler training, or patience, courage, dauntless devotion, nobler opportunities of exercise than in the war with evil?

The Rev. Dr. Ferguson, of Strathblane, has a powerful discourse on "Law and Miracle," in which he says:

Christianity, then, is no rigid system of dogma, or of ecclesiastical forms elaborated long ago and incapable of growth or change. It is rather a living organism, drawing nourishment to itself from every side, and affected by the life-pulsations of every age. Look, for instance, what a vast difference between Christianity in the first and in the nineteenth century! Then it was struggling for existence between Judaism on the one hand and paganism on the other; now it has conquered its position, and extorts recognition at least from its bitterest opponents. It has revolutionized the whole structure of society, and formed manners and customs and habits of thought.

Of the effects produced by this habit of sifting and winnowing which goes on in history, we have a good example in the doctrine of miracle. In our own day that doctrine does not occupy the prominent position it formerly had. It has fallen into the background, and lost its apologetic value; but, at the same time, its actual relations to the circle of Christian truth have been made clear. In the course of last century, on the contrary, the sharpest attacks which Christianity had to sustain were directed against

this side. The contest raged round the credibility or incredibility of miracle, as if the whole of revelation depended upon the issue. In reality, however, no vital point of revelation was endangered. It was an affair of outposts altogether, and the work so energetically assaulted and defended had little importance for the citadel in the rear. Neither the philosopher who argued against nor the divine who contended for miracle was dealing with the essence of Christianity, and the complete triumph of either would have made little change. At the worst, a dogma of the Church would have been overthrown; but the dogmas of the Church and the religion of Christ are not synonymous terms.

In enumerating the various causes which have produced a new "climate of opinion" in relation to miracles, Dr. Ferguson says:

First of all, there is the scientific conception of the universality of law. This may truly be said to be the revelation of our own age, not in the sense that it was unknown to our predecessors, but that in the present day the conception has been so extended and generalized as to dwarf its former proportions. It has passed out of the laboratory of science into the common possession of men, and is now one of the great truths so firmly established that they become truisms. We never stop to reason about them, and, were any one rash enough to call them in question, we should not give him even a patient hearing. Moreover, the idea of law is not to be confined to the material world, with its indestructible treasury of force. It must be carried over into the world of mind, and be seen at work there also, not indeed with the rigidity of physical law, but within the large limits which freedom of thought and action demands. It is to be traced in the advance of civilization, in the development of history, in the growth of religion, in relations such as those between morals and art, between society and government, between national life and literature. Now, it is not difficult to see how such a conception must indispose men under its influence to look favorably upon miracle. In the idea of order everywhere supreme, calm, eternal, there is a sublimity which fills their imagination and stimulates their intellect. Any interruption of its uniform course, any breach of continuity, would be a blemish in the picture, and not an additional charm—would be, indeed, a positive pain to thought, and, instead of disposing the mind to reverence, would fill it with confusion and doubt.

The Rev. Professor Knight, of St. Andrews, has a sermon of great interest and moment on "The Continuity and Development of Religion," in which he says:

It does not, therefore, follow that, if we can explain the origin of a particular belief by tracing its parentage, and finding that it has sprung from inferior elements, the validity of the belief itself is in the slightest degree imperiled. Nay, it is indisputable that, if the human mind has grown at all, its religious convictions—like everything else belonging to it—must have changed. Our remote ancestors could not possibly have had the same religion as ourselves, any more than they could have had the same physiognomy, the same social customs, or the same language. Thus, the intuitions of subsequent ages must necessarily have become keener and clearer, at once more rational and more spiritual, than the instincts of primeval days; the clearness, the intelligence, and the spirituality being due to a vast number of conspiring causes. And, if the opinions and the practices of the race thus change, the change is due to no accident or caprice, but to the ordinary processes of natural law. It can not be otherwise; because, since no human belief springs up miraculously, none can be maintained in the form in which it arises for any length of time. Thus, the "increasing purpose" of the ages must inevitably bring to the front fresh modifications of belief. If our theologies have all grown out of something very different, why should we fear their continued growth? Why should any rational theist dread the future expansion of theistic belief? If it has grown, it must continue to grow, and many of its existing phases must disappear. The controversies of our time are the phases of its evolution. But is it now so very perfect that we would wish it to remain stationary at its present point of development? That its present phases should be permanent? May we not rather rejoice that "these all shall wax old as a garment," and that, "as a vesture, they shall be changed"; while the Object—of which they are the interpretation, or which they try to represent—endures, and of its immortality there shall be no end? It may even be affirmed that one of the best features in every human belief is its elasticity; that one sign of its vitality is its amenability to change. Were it irrevocably fixed, it would have some secret affinity with death and the grave. Paradoxical, therefore, as it may seem, if religion be among the things that can not be shaken, it must change. Its forms must die that its spirit may live: and the condition of the permanence of the latter is the perpetual vicissitude of the former. Curious it is that some of its most ardent advocates can not recognize it under a new dress, that even its disciples misconstrue it when it changes its raiment. They think it a foe if it is differently appareled. But how often in all human controversy the combatants are merely speaking different dialects while they mean the same thing! But, granting that the opinion of the world is an organic whole, that all human conviction—with its present variety and complexity—has grown out of very lowly roots, and that our most sacred beliefs have emerged from others that are different, a further and a far more important question lies behind this admission. It is this: How are we to interpret the whole series from beginning to end? It is not enough to say that there has been progress; what meaning are we to attach to the term progress? Are we to think of it as simple succession and accumulation, the mere addition of new links to a chain of devel-

opment? We know that men "rise on stepping-stones of their dead selves to higher things," and that the "individual withers, while the race is more and more"; but do the individuals and their beliefs only resemble beads which have been strung on a thread of endlessly developing succession? What has the race been *doing* during all this onward process of development? And has it at every stage been the victim of continuous illusion? Or has it all the while been in the closest contact with Reality, a reality which it partially understands, and interprets to good purpose? In other words, is the history of religious ideas merely the record of attempts made by men to project their own image outward, to throw their thought around an impalpable object which it has never yet been able to grasp? Or is it the story of successive efforts, more and more successful, to explain a reality which transcends it, but to which it stands in a definite and ascertainable relation? Do the gropings of experience in the matters of religion record a long and weary search, with no discovery rewarding it? Or are they the efforts of human apprehension to realize the divine, to get at the "last clear elements of things," with disclosure at every stage, and a steady approach to the goal which is continually sought and approximately reached? I think it is past controversy that if the religious education of the human race has been a purely subjective process, if it has been merely an upward tendency of aspiration, it is now no nearer its goal than ever it was. If we can only approach the Infinite by the journeyings of finite thought or through sighs and cries of aspiration, the journey that way is endless, and the end is nowhere visible. But may we not find the object everywhere? May not the discovery have been as continuous as the search, and the two be simultaneous now? I think that we may affirm that the human race has lived in the light of a never-ceasing apocalypse, growing clearer through the ages, but never absent from the world since the first age began.

Modern Thinkers: Principally upon Social Science. What they Think, and why. By Van Buren Denslow, LL. D. With an Introduction by Robert G. Ingersoll. With Eight Portraits. Chicago: Belford, Clark & Co. Pp. 384.

This volume consists of a series of brief personal sketches of several of the leading thinkers of modern times, together with critical disquisitions on their labors, influence, and character. The thinkers selected for study are all of the aggressive or revolutionary type, and they were chosen furthermore because of the more or less intimate bearing of their advanced ideas on the subject of social science. Three Englishmen, Adam Smith, Jeremy Bentham, and Herbert Spencer; two Frenchmen, August Comte and Charles Fourier; a Swede, Emanuel Swedenborg; a German, Ernst Haeckel; and an American, Thomas Paine—are the characters selected for examination.

The author has a brief preface explaining the origin of his book, and offering some preliminary suggestions regarding its method and purpose. The essays were written for the "Chicago Times," and at the suggestion of its editor they were first published in that newspaper. The intelligent interest elicited by them has induced the author to bring them out in this more permanent form. It was an excellent idea, and does credit to the editorial sagacity and liberality of Mr. Storey. People are undoubtedly more and more confining themselves to the reading furnished by newspapers, and we see no reason why, under the pretext that their business is the promulgation of news, the daily press should confine itself exclusively to the scattering of information on ephemeral and frivolous subjects.

Colonel Robert J. Ingersoll contributes a spicy introduction to the volume, briefly presenting his views of the various characters it deals with, and pointedly reillustrating his well-known anti-theological position. In this, however, he is in entire harmony with the spirit of the volume, which is characterized throughout by hostility to everything theological, and abounds in unsparing invectives against the Church, the priesthood, and the Christian gospel. The work is written in a free, vivacious, and somewhat dashing style, and is eminently readable. The mode of treating the subjects is independent, sensational, and bold. Much of its exposition is instructive, evincing good preparation; and much of it will be unsatisfactory to those who prize deliberate and unprejudiced work. As a piece of manufacture, the volume itself is no credit to Chicago.

The essay that has most interested us is on the American subject, Thomas Paine, whom the author regards as the "representative critic, destroyer, and revolutionist of his period.... He was gifted, as no man ever was before or since, with the fatal and unhappy faculty of suppressing the good and

exaggerating the ill in the men upon whose conduct he was called to comment, and in the institutions he aimed to overturn." Dr. Denslow makes out a specious case for Paine as the author of the "Letters of Junius"; but Mr. Ingersoll interposes to protect the great freethinker against this scandalous imputation, and protests that Paine "was neither a coward, a calumniator, nor a sneak," and he gives a few reasons that are weighty against the hypothesis that Paine was the author of these celebrated letters.

Dr. Denslow maintains, with more show of reason, that he wrote the "Declaration of Independence," and Mr. Ingersoll is inclined to think that this claim is well founded. Decisive reasons are given why Jefferson could not have been its author, and there is much forcible evidence that Paine was the only man who could have done it. The following passages will afford a good illustration of our author's manner of dealing with his topics, and also sum up his estimate of Mr. Paine:

But, enough! The Declaration of Independence must hereafter be construed as a fabric whose warp and woof were Thomas Paine's. It was admirably adapted, as a revolutionary *pronunciamiento*, to fire the colonial heart to a war for separation which, though placed on utterly inadequate and untenable grounds by that Declaration, yet had good grounds which are not mentioned in it. Those were, simply, that not having any of the materials for an aristocracy in this country, we could not coalesce into one government with Great Britain, whose government was aristocratic. If we had been permitted to elect members to her House of Commons, what should we have sent to her House of Lords? The alleged grievance of taxation to reimburse the British Treasury for expenses incurred in our defense was in no sense a money grievance. The money having been expended for our benefit, it was our duty to pay it. There could surely be no duty resting on Londoners or Yorkshiremen to pay the expenses of Montgomery's march to Quebec or Braddock's to Pittsburgh. The real difficulty was, that we needed a sovereign government, and could not be admitted into the British one, because that was aristocratic and we had no aristocracy. This was not a grievance, but it was a good cause for national separation. The Declaration, like many popular documents, substituted sentiment for sense, passion for wisdom, fiction and rhetoric for history and fact, concealed the double merits of the case and helped on the war, in the same way that the stupidity of George III did.

We may now fairly estimate Thomas Paine in his two most marked characters, as a master of rhetorical invective and as a revolutionist; for, after attributing to him the authorship both of "Junius" and of the Declaration of Independence, as well as "Common Sense," "The Crisis," and "The Rights of Man," he still subsides into the category of brilliant sensational agitators endowed with a considerable force of prophetic insight, who fell far short of the qualifications essential to a statesman, or even of the appreciation of what statesmanship is. There can be no statesmanship without cool-headed candor, judicial calmness, capacity for guarded, just, and moderate statement, which will bear the test of time, perfect fairness toward adversaries, gratitude toward supporters, and a capacity for harmonizing adverse or conflicting elements by practicing, in non-essentials, unity, and in essentials, charity. Webster, Clay, Calhoun, Hamilton, Madison, Washington, and Franklin possessed these qualities, but Paine, the scathing and withering accuser, lacked them all. If it be a galling and unbearable tyranny for a conscientious man, with a tongue that has an infinite capacity for accusation, and none for pardon, to go about, like a section of the day of judgment, applying to every one who stands in his way such exacting and ideal tests and standards of virtue that human nature, which seems very tolerable to those who are looking at it without the blasting motive, is foredoomed by it to certain damnation and infamy, then Paine was a species of moral tyrant, always demanding the impossible of others. Notwithstanding his profession and belief that he was an apostle of freedom, Paine's fundamental belief in politics was that the government was always wrong, that it was inherently an evil; that the less there was of it the better, but that, however reduced in dimensions, whatever should be left of it would still be bad by reason of its being government. It was as wrong when vested in Washington as in George III, and he had good reason to know that it was as wrong when wielded by Robespierre as when presided over by Louis XVI. On the contrary, Paine imagined that the aggregated ignorance and incapacity of all the vast unskilled millions who had been pushed out of the work of government by the superior force and cunning of those in power were the actual repository of political wisdom and purity. The iceberg needed only turning over. He began with the creed, which he retained to his death, that government was not an affair of skill, but merely of honesty; not a problem of difficulty, but merely of good intentions. Holding these views, it followed that if it could in some way be got out of the hands of the skilled and interested few who were educated to it, and had made a profit out of it, into the hands of the unskilled and disinterested masses, who were not educated to it, and who, he assumed, would not seek to make a profit out of it, then good government would be perfectly secured. The inverted iceberg would bloom into an enchanted island, melodious with the songs of birds and mellifluous with the scent of flowers. It did not occur to him that the hereditary principle in government might sup-

ply permanency, nationality, and non-partisanship to the executive, while an elected executive would always be the mere chief of a party and never the head of a nation; or that the bungling charlatanism of the unskilled democracy might result in misgovernment, waste, despotism, and passionate folly. So little did he comprehend both sides of the question, that, in "The Rights of Man," he predicted that within ten years the monarchical and aristocratic principles would have disappeared from all enlightened governments of Europe. The instant his supposed government of the people had got under way in America, Paine immediately saw in it an oligarchy in power, new in personality, but not materially different in meanness and avarice.

The Scientific Basis of Spiritualism. By Epes Sargent. Boston: Colby & Rich. Pp. 372. Price, $1.50.

This work, copyrighted in 1880, has but just appeared, but since its publication its versatile author has passed away. Mr. Sargent was born in 1812, studied in Harvard College, and early became an editor in Boston. He pursued this vocation awhile in New York, and then again resumed it in Boston. He edited various popular "Speakers," "Readers," and rhetorical books for the schools, and wrote many plays both comical and tragical. He also wrote "Life of Henry Clay," a volume of poems, an abolition book, and "Arctic Adventures." That he should have dipped into spiritualism was but natural with his love of diversified literary occupation; and so, a dozen years ago, he printed "Planchette, or the Despair of Science," and closed his career with the production of the volume now before us.

As was to be expected, the work is one of considerable literary merit, well digested, attractively written, and made lively by a pervading spirit of criticism. If we may be allowed the paradoxical suggestion, Mr. Sargent goes the "whole hog" in spiritualism. He believes it all, sticks at nothing, and slashes right and left at everybody who objects to it. He claims to be on the winning side, and says that in the last forty years spiritualism has gained twenty million adherents. One would think that with this he might "rest and be thankful," but it does not satisfy him. It seems that, among these twenty million believers, the scientific men generally are not to be found, and it is this fact which caused Mr. Sargent to write his book. He thinks the twenty million people of all sorts, who need not be further characterized, are right, and that the scientific men—the sole class whose business it is to search out the truths of nature—are wrong; and it is his object to show that spiritualism has just as much a valid scientific foundation as any of the recognized and established branches of science. We shall not undertake to answer his arguments, if such they may be called, but will only observe, as we have repeatedly done before in this connection, that the most fundamental of all distinctions is confused throughout the work. The supernatural, or that which by its very term is above and beyond nature, is mixed up and confounded with nature itself, and spiritualism is declared to be "a purely natural fact." Yet, if this doctrine had twenty times twenty million adherents, science could not accept it, because it takes for its object of investigation the natural as opposed to the supernatural. In so far as alleged "spiritualism" involves human phenomena, it is of course within the purview of science, and scientific men will be certain to take these phenomena up in their own way and in their own time. But they must be allowed to mark out their own work, and the problem as presented by the twenty million does not come in a shape suitable to be dealt with by rigorous scientific methods. The men of science begin by doubting, and cultivating this state of mind as a virtue; they continue to doubt until evidence extorts acquiescence, while assent even then goes no further than to things regarded as actually proved; the "twenty million," on the contrary, begin by believing, hold this state of mind to be a virtue, and go on believing without much perplexing themselves over questions of evidence. To them the phrase "the scientific basis of the super-scientific" would involve no contradiction.

Progress and Poverty; an Inquiry into the Cause of Industrial Depressions and of Increase of Want with Increase of Wealth: The Remedy. By Henry George. New York: D. Appleton & Co. Pp. 512. Cheap edition, with a new preface, in paper cover. Price, 75 cents.

We are glad to announce the appearance of a cheap popular edition of this suggestive book, by which it will be made accessible

to many who could not have secured it in its previous form. We are happy to note, further, that it has proved a very considerable success. Four editions have been called for in this country; the Germans are printing a translation in parts; it is discussed in French and Italian periodicals; and an English edition is in preparation. The work is everywhere looked upon as an important contribution to political economy, and as an eloquent and vigorous discussion of imminent social problems. It is a wholesome sign of the growing liberality of the times that a work should be so cordially received and highly appreciated, while at the same time there is general and decisive dissent from its main conclusions. It is read and enjoyed for its humane spirit and the novelty and independence of its views; but we do not observe that Mr. George makes disciples who endorse his leading and distinctive doctrines. It is, however, admitted that he has contributed to the elucidation of political economy by his adverse criticism of prevailing opinions on that subject; and it is certainly no small merit to have done something for the advancement of this inquiry, and the clearing up of important economical questions.

Medical Heresies historically considered. A Series of Critical Essays on the Origin and Evolution of Sectarian Medicine, embracing a Special Sketch and Review of Homœopathy, Past and Present. By Gonsalvo C. Smythe, A. M., M. D., Professor of the Practice of Medicine, Central College of Physicians and Surgeons, Indianapolis. Philadelphia: Presley Blakiston. Pp. 228. Price, $1.25.

It was not the author's object in this volume to write a history of medicine, but simply to sketch the rise and fall of the different schools, sects, or systems of medicine, from the earliest historical period down to some of the more prominent heresies of the present day. The author writes with brevity, and does not enter into the consideration of the contemporaneous systems of philosophy or theology with which medicine in former times has been strangely and inconsistently commingled. All topics are also avoided which are merely of interest to the medical antiquarian. The author says in his preface: "My second object is to furnish the regular profession with some much-needed information in regard to homœopathy. Few busy practitioners have the time or inclination to investigate the claims of this school, and, although they are brought in contact with it daily, know little or nothing of its real principles. I have presented the principles of this school fairly, quoting the exact words of its founders at the expense of some repetition, in order that I might not be accused of misrepresentation. The discussion of these principles has been conducted from a scientific standpoint, and without ridicule, thus showing of what homœopathy consisted originally; and by quotations from the current literature of the school, with discussions thereon, showing what it is now. It is confidently believed that the condensed information contained in this little book will not be altogether without interest to the profession."

Passages from the Prose Writings of Matthew Arnold. New York: Macmillan & Co. Pp. 333. Price, $1.50.

Not only will the admirers of Matthew Arnold be gratified by this varied collection of his best utterances, but many, who are not familiar with or do not possess his works, will be glad of a representative volume like this, in which they can get some acquaintance with the thought of the eminent modern apostle of the gospel of "sweetness and light." The selections are systematic, being arranged under the heads of—I. Literature; II. Politics and Society; and III. Philosophy and Religion; and they have been collected with good judgment, and will prove very suggestive and gratifying to all cultivated readers.

The Journal of Physiology. Edited by Michael Foster, M. D., F. R. S., of Trinity College, Cambridge. Assisted in England by Drs. Gamgee, Rutherford, and Burdon-Sanderson; and in the United States by Drs. Bowditch, Martin, and Wood. New York: Macmillan & Co. No. 1, Vol. III.

We call renewed attention to this admirable periodical, the only one in English thoroughly devoted to original physiological research. The progress in the arts of physiological experimentation and the untiring assiduity of the laborers in this field are fruitful of important results which are

both of general interest as extensions of scientific knowledge and of special moment to all the well-qualified members of the medical profession. The publication deserves to be liberally sustained.

The Beautiful and the Sublime. An Analysis of these Emotions, and a Determination of the Objectivity of Beauty. By John Steinfort Kedney. New York: G. P. Putnam's Sons. Pp. 214. Price, $1.25.

This is not a text-book on æsthetics, but an attempt to deal with the underlying philosophy of the subject. Physical science, metaphysics, and theology profess to be no more dealt with than is necessary for the author's logical purpose. His chief claims are on the psychologic and the ethic side, and there he thinks he has made additions to the treatment of the subject. He does not attempt to deal formally with art or art criticism, but holds that his views may be carried out in application to the several departments of architecture, sculpture, painting, music, literature, oratory, poetry, and histrionics. The author modestly says in his preface: "While my treatise is intended, primarily, as a contribution to the philosophy of the science, I have endeavored to cast it in such form and style as to interest all intelligent readers, who, if they are patient over some parts of the work, may find it, elsewhere, and on the whole, compensatory."

A New School Physiology. By Richard J. Dunglison, A. M., M. D. 119 Engravings. Philadelphia: Porter & Coates. Pp. 314. Price, $1.50.

This school-book has several things to commend it: it is neatly printed, it is elegantly illustrated, it carries an eminent name on its title-page as author, and is, consequently, we have no doubt, trustworthy in its statements; if, therefore, the publishers can not make a good thing out of it, it will be their fault. The drawback of the book is, that its author seems to know only physiology, while some knowledge of the growing mind is necessary to make a good book of science for educational purposes. It is a question-and-answer book "of the old type," to be learned by memory by young people. As this class embraces pupils of all grades, the book is suited to no special grade, and will be equally used to begin with, to continue with, and to finish with. This will be again favorable to its sale, but unfits it for intelligent educational use.

Diphtheria: Its Cause, Nature, and Treatment. By Rollin R. Gregg, M. D. Pp. 137. Price, $1.50.

On the title-page of this book is printed the following, which are probably fundamental propositions maintained in the volume: "Spherical Bacteria, or Micrococci of Diphtheria, shown to be only Molecular Granules of Fibrin. Rod-like Bacteria, Bacterian termo, shown to be Molecular Granules of Fibrin, united into Fibrils, or fine thread-like prolongations."

The book is one that it belongs to the medical profession to judge of.

PUBLICATIONS RECEIVED.

Cases treated by the Lister Method. Reported to the Portland Clinical Society by Frederick H. Gerrish, M. D. Portland, 1880. Pp. 15.

The Anarchist. Socialistic-Revolutionary Review. Edited and publishd by Dr. Nathan Ganz. Boston, January, 1881. Monthly. Pp. 24. 60 cents a year.

Vennor's Almanac and Weather Record for 1880-'81. New York: American News Company. Pp. 84. 25 cents.

Annals of the New York Academy of Sciences. Vol. I. Nos. 11, 12, March, and No. 13, April, 1880. New York: Published for the Academy.

The Constitution of the Tartrates of Antimony. By Professor F. W. Clarke and Helena Stallo. Reprint from "American Chemical Journal." Pp. 13.

Reports of the Iowa Weather Service for the Twelve Months of 1878, and January, February, March, and April, 1879. By Dr. Gustavus Hinrichs. Des Moines, 1880.

Dictionary of Music and Musicians. Edited by George Grove, D. C. L. Part XII, Palestrina to Plain Song. London and New York: Macmillan & Co. 1880. Issued in quarterly parts, at $1.

Report on the Culture of the Sugar-Beet and the Manufacture of Sugar therefrom in France and the United States. By William McMurtrie, Ph. D. Washington: Government Printing-Office. 1880. With Maps. Pp. 294.

A Treatise on the Injurious and Beneficial Insects found on the Orange-Trees of Florida. By William H. Ashmead. Jacksonville, Fla. 1880. Illustrated. Pp. 78.

The Food of Fishes. By S. A. Forbes. Reprint from Bulletin No. 3. Illustrated. State Laboratory of Natural History. Pp. 60.

On the Present Condition of Musical Pitch in Boston and Vicinity. By Charles R. Cross and William T. Miller. Reprint from the "American Journal of Otology," October, 1880. Pp. 16.

The Coming Revelation: Its Principles. St. Louis, 1878. Pp. 40.

The Abdominal Method of Singing and Breathing as a Cause of Female Weakness. By Clifton E. Wing, M. D. Boston. Pp. 8.

Abridgment of the Nautical Almanac for 1881. By Riggs & Brother, Philadelphia. Pp. 150. 25 cents.

The Geological and Natural History Survey of Minnesota. Eighth Annual Report, for 1879. By N. H. Winchell. Illustrated. St. Paul, 1880. Pp. 183.

Drainage for Health, or Easy Lessons in Sanitary Science. By Joseph Wilson, M. D. Philadelphia: Presley Blakiston. 1881. Pp. 68. $1.

Report of the United States Fish Commissioner for 1878. Washington: Government Printing-Office. 1880. Pp. 988.

Introduction to the Study of Indian Languages. With Words, Phrases, and Sentences to be collected. By J. W. Powell. Washington: Government Printing-Office. With Maps. 1880. Pp. 228.

James Smithson and his Bequest. By William J. Rhees. Washington: Published by the Smithsonian Institution. Illustrated. 1880. Pp. 159.

Sketches and Reminiscences of the Radical Club of Chestnut Street, Boston. Edited by Mrs. John T. Sargent. Boston: J. R. Osgood & Co. 1880. Pp. 418. $2.

The Logic of Christian Evidences. By G. Frederick Wright. Andover: Warren F. Draper. 1880. Pp. 312. $1.50.

Extracts from Chordal's Letter. American Machinists' Publishing Company. New York, 1880. Pp. 320. $1.50.

Elementary Projection Drawing. By S. Edward Warren, C. E. New York: John Wiley & Sons. Twenty-four Plates. 1880. Pp. 162. $1.50.

A Text-Book of Elementary Mechanics. By Edward S. Dana. New York: John Wiley & Sons. 1881. Pp. 291. $1.50.

The Young Folks' Cyclopædia of Persons and Places. Illustrated. By John D, Champlin, Jr. New York: Henry Holt & Co. 1881. Pp. 936. $3.50.

POPULAR MISCELLANY.

The Age of the Trenton Gravels.—The age of the gravel in which flint implements have been found at Trenton, New Jersey, is carefully discussed by Mr. Henry Carvill Lewis, in a paper read by him before the Academy of Natural Sciences of Philadelphia. Mr. Lewis divides the surface formations of southeastern Pennsylvania into five clays and four gravels, of which nine deposits the Trenton gravel, as he calls the implement-bearing formation, is, except the recent alluvium, the most recent. At Philadelphia it is called the river-gravel and sand, and contains pebbles which are made exclusively from the rocks forming the upper valley of the Delaware River, and which have the flat shape characteristic of all true river-gravels. It is confined to the immediate vicinity of the river, and has been traced as far up as the Water-Gap. Throughout its whole course it lies within a channel previously excavated through the bowlder-bearing Philadelphia brick-clay and its red gravel, which have been shown to belong to the Champlain epoch. It is therefore later than those formations. The deposit is spread out to its greatest extent at Trenton, where the long, narrow valley of the Delaware, with its precipitous banks and continuous downward slope, opens out into the wide, alluvial plain at a lower level. The fluviatile character of this gravel is shown by evidence of various characters, as by the exposures of the "flow-and-plunge structure," in which the layers are seen to dip up-stream, as would be expected to result from the action of downward-flowing water, while the tertiary gravels show in their layers, dipping southeast, evidence of their deposition by incoming oceanic tides. It frequently, also, instead of lying in a flat plain, forms banks with a higher ground close to the present river-channel, and sloping down toward the ancient bank, as often takes place according to the laws of river deposits. The formation can not, however, have been made under the operation of any such flood as has been known within the historical epoch, for no such flood has supplied the amount of water which would be required. It also bears marks of ice-action. It may then be ascribed to a glacier; not to the great glacier of the glacial period, for that glacier at its melting deposited the much older brick-clay and red gravel, but to another more recent glacier whose flood flowed through a channel excavated in the deposits of the first glacial period. This second glacier was much smaller than the first, had its southern extremity confined to the valley, and probably corresponded with the age which European geologists style the *Reindeer period*. From the fact that the palæoliths found here are similar to the stone implements found among the Esquimaux, Mr. Lewis thinks that they may be the relics of an Esquimau race who once lived in the valley, and he suggests the *Esquimau period* as a suitable name for their age. Finally, he sums up his conclusions as follows: "1. That the Trenton gravel, the only gravel in which implements occur, is a true river deposit of post-glacial age, and

the most recent of all the gravels of the Delaware Valley. 2. That the palæoliths found in it really belong to and are a part of the gravel, and that they indicate the existence of man in a rude state at a time when the flooded river flowed on top of this gravel. 3. That the data do not necessarily prove, geologically considered, an extreme antiquity of man in Eastern America."

Prehistoric Mining in North Carolina.—Mining for mica has become a profitable pursuit in North Carolina. It is a curious fact that the best mines are located upon sites which afford evidence of having been worked in prehistoric times, and are called there "old diggings." Most of the old works probably belonged to the mound-builders, but a tradition coming down from the Indians ascribes some of them to white men. The tradition has recently been confirmed by the discovery of old implements of iron in a prehistoric shaft in Macon County, which are fully described and figured by Mr. F. W. Simonds, in the "American Naturalist." The implements were found in the rubbish which had accumulated within the shaft, between thirty-five and fifty feet below the surface, and consist of an axe of a pattern now rarely met with, light in weight, and having on the blade a brand which has been nearly effaced by erosion; two articles which were evidently gudgeons of a windlass, with heads pronged for the insertion of levers, pointed at the ends, so that they could be driven into a wooden roller, and having the lower part of the shank squared to prevent their turning in the wood, and the upper part round so as to serve as an axle for the roller; and a wedge with battered head. All were of wrought iron, and had probably been worn out and thrown away. Mr. Simonds suggests that they are the relics of a party of Spaniards who left one of the ancient colonies or expeditions on a "prospecting tour" and tried the mines. Less palpable evidences of more skillful mining than that of any aborigines have been found in other shafts.

The Great Glacier of the Yellowstone.—Professor Archibald Geikie, Director of the Geological Survey of Scotland, gives in the "American Naturalist" an interesting notice, based on his personal observations, of the ancient glaciers of the Rocky Mountains. He refers to the absence of signs of glacial action in the region between the Missouri Valley and the Sierra Nevada, which has been mentioned by American geologists, and regards it as the result chiefly of meteorological conditions. Then, having spoken well of the accounts given of the glaciers of the mountains by our geologists, he records his own observations of them. Entering the Yellowstone Valley from Fort Ellis, a little above the first cañon, he observed a prominent rock like a cottage, and weighing more than a hundred and fifty tons, lying, like other smaller erratics around it, on crescent-shaped mounds—moraine-heaps—in the midst of the alluvial plain. The broad valley was full of moraine-stuff. Here, he observes, was a great glacier moving northward, "while in British Columbia, on a parallel only about two hundred and fifty miles farther north, there was a massive ice-sheet moving southward. It will be a point of no little interest to trace these two converging ice-streams toward each other." In ascending the Yellowstone Valley toward the National Park, scattered moraine-mounds and abundant transported blocks continue to denote the course and size of the former glacier. The intense glaciation of the second cañon was a surprise. The rocky knobs at the lower entrance of the great ravine were as perfectly smooth, polished, and striated as the rocks at the margin of any Swiss or Norwegian glacier, and the steep sides of the cañon had been ground and striated in the same way, to the height of certainly not less than eight hundred feet. Above the second cañon the moraine-heaps become more abundant and tumultuous, here and there inclosing small lakes; and they were found also, with erratics, in the tributary valleys. The trail from the Mammoth Springs by Blacktail Deer Creek, over to the Yellowstone, leads across mounds of glacial *débris* among which huge bowlders of granite and granitoid gneiss are conspicuous. Some parts of the route present long, smooth slopes, dotted with bowlders precisely like some Scottish bowlder-clay moors. These signs of glaciation can be traced up to and

across the water-shed leading over to the Yellowstone Valley, and "they prove beyond question that not only was that valley filled up with ice, but that the glacier plowed over the ridge one thousand feet above the valley-bottom and passed into the country lying to the westward." Professor Geikie made an estimate of the thickness of the ice, from the indications afforded by the position of the highest erratics which he observed on the slopes of Mount Washburn, from which he concludes that it could not have been less than sixteen hundred and fifty, and was probably at least nineteen hundred feet. It is clear to him, from all the evidence, that the ice of the Yellowstone Valley was more than that of a mere local or valley glacier. It was massive enough to fill up the main valley and override the surrounding hills, crossing minor water-sheds and spreading into adjacent drainage basins; and he believes it may be eventually shown that the snow-fields of the Wind River and Teton ranges were so extensive that their ice-rivers streamed northward across the buried water-shed, and poured into the Yellowstone. An exploration of the country lying in the Yellowstone Valley, northward into the area of northern glaciation within the British line, is desirable to show whether there was any connection between the glaciers of the Rocky Mountains and the great northern ice-sheet, and whether the latter, as it moved down the valley of the Missouri, was swelled by the accession of ice-streams from the mountains.

Structural Peculiarities of the Eel.—Frank Buckland gives an interesting description of the curious yet simple apparatus by means of which the eel is able to keep his gills moist without taking in fresh water, and thereby to live a long time out of water and travel on land for a considerable distance. Close to the pectoral fin of the eel is a slit which acts as a valve, connecting with a large cavity inside of which are the gills. This cavity the eel has the power of filling with water, and of keeping within it a supply which prevents the gill-fibers from adhering together so as to stop respiration. It is surrounded by a loose membrane, and is filled and emptied by means of a curious bit of mechanism which is thus described: "A framework of very delicate bones, each bone connected with its neighbor by an elastic membrane of the consistency of gold-beater's-skin, forms a fan-shaped covering over the gills; its action is very like, if not the same as, the action of an umbrella. When the eel wishes to take in his water-supply, he, as it were, opens his umbrella-shaped framework and fills his reservoir; when he wishes to expel the water, he, as it were, closes his umbrella." When an eel is taken out of the water he will soon expand his reservoir, and swellings will appear on either side of his head. He will shortly wish to refill his reservoir, and, if given water, will immediately take in a considerable quantity. With this he is ready to take an overland journey if he wishes to change his abode. The eye of the eel is protected against the mud, stones, etc., among which he lives by what Mr. Buckland calls a wonderful spectacle or eye-glass, formed by the conversion of the skin of the head where it passes over the eye into a thin but strong transparent membrane, which forms an admirable guard against injury.

Split Stones in the Desert.—Those parts of the desert of Sahara called the Hamadas—which are also among the most desolate tracts of the region—are strewed with siliceous pebbles which are all broken up, presenting sharp edges, as if they had just been split with a hammer. Sometimes fragments of these pebbles could be found lying together with their fractured sides facing each other and fitting perfectly when brought close together. The phenomenon has baffled explanation for a long time. M. J. Brun has recently communicated to the Scientific Society of Geneva his conclusion that it is the result of a curious combination of chemical and mechanical actions. He found by analysis that the sand of the desert was composed of quartz, gypsum, and marl, with traces of salt. The quartz-grains act under the influence of the solar rays as burning-lenses upon the gypsum, and render it anhydrous. The sand and fine anhydrous gypsum-dust are driven about by the winds and cover all the stones; the dust penetrates the little cracks in the stones, when it is wet by the dews, and swells. With continuous ac-

cessions of gypsum and repeated heavy dews the accumulation of plaster goes on increasing, the cracks are enlarged, and in time the stone is split.

Variations in the Forms of Water-Plants.—Dr. W. Behrens, of Brunswick, has published a preliminary report of researches which he has been making into the influence of the movement, and other physical relations, of water upon the plants growing in it. He observes that water-plants, both those that grow submerged and those which appear on the surface, are subject to a variety of modifications in the forms of their stems, leaves, and other organs, according as the water in which they grow is in more or less lively motion. Plants which grow in a stream, and are rooted in the ground, seem to receive a kind of pull from the moving force of the water, which is proportioned to the speed of the current. If plants which grow indifferently in standing, moderately moving, and swift waters, exhibit variations which are constant for the same kind of waters, the conclusion is allowable that the variations are produced by the kinetic influence of the waters. Plants which are met in only one kind of waters do not exhibit equivalent variations. The common frogbit, of Europe, which floats on the surface of still waters, has its leaves always of the same broad kidney-form. The pond-weed, which grows both in still and running waters, exhibits, on the other hand, manifold variations. The most common form has floating, oval leaves, the diameters of which are to each other as 1 to 1·5. The leaves of those varieties that grow in running water are longer and narrower in proportion to the swiftness of the stream; and one form is mentioned in which the diameters of the leaves are as 1 to 3. The water-ranunculuses (Batrachium) afford excellent examples of the influence of running water on the forms of plants. Several species are found in all kinds of waters, the most of them having leaves of two forms, peltate floating leaves, and much divided submerged leaves. They grow in still and running, fresh and brackish waters, and even on the land after the water has dried away. Of the species common in Europe, *Batrachium aquatile* is the most interesting object of study in respect to its variations. Its forms are numerous, but they may be arranged under two general heads. The first includes those varieties which have plain floating leaves and also divided, submerged leaves, and the second those which have only divided leaves under water. The forms of the former class occur principally in waters having little motion; the floating leaves are round and peltate, with fine slight scallops on the borders. In swifter waters the leaves are cut up into pointed lobes, the distinctness of which increases with the speed of the current. Dr. Behrens has distinguished about thirty varieties in different waters, most of which he has described and named in his paper. In the swiftest currents, the floating leaves disappear, and only the varieties of the second form—those having exclusively divided, submerged leaves—are found. Still another change comes over the Batrachium when the water is taken away from it. It grows up with a short stem, and is thickly covered with geeen leaves divided into numerous short, firm, succulent lobes. Dr. Behrens is preparing a work in which variations of this sort will be fully discussed, with illustrations.

Progress in Photography.—"Some Recent Advances in Photography" is the subject of a paper recently read before the Society of Arts by Captain Abney, R. E., F. R. S., in which reference was made to the more important improvements in the art that have been put in practice since 1875. A new negative process, called the gelatino-bromide process, offers decided advantages. It consists in the use of a gelatine emulsion of silver bromide for the sensitive surface. With a plate thus prepared, a photograph may now be taken in one second of time which it formerly took thirty seconds to secure; and a plate can be prepared which needs an exposure of only one sixtieth of a second, when a view is fairly lighted to secure a soft and harmonious negative. It makes instantaneous views possible under circumstances which were impossible, in illustration of which the speaker exhibited a view in which the shadow and reflection of a swallow passing in the air over a pond were perfectly represented. The plates and the development of pictures

taken by this process are perfectly clean. The plates, moreover, have the quality of preserving the impressed image for a long time after they have been exposed and before it has been developed. The chief disadvantage of the process is that the photographer using it has very little power to give local intensity to his picture. Till lately, a red light had to be employed in the developing-room, and this was painful to the operator. The difficulty has been obviated by adding iodide of silver to the emulsion in the proportion of one part of iodide to eight of the bromide, when an orange light can be used with impunity, and the shadows are given a wonderful clearness. When a collodion emulsion is adapted to a flexible support and used for the negatives, the operator is able to do away with glass and its weight, and may store rolls of sensitive material in the camera itself. Then, by turning a screw, he may place fresh portions of the band in a condition for exposure. After exposure, paper prepared with this emulsion may be moistened with turpentine, and the film bearing the image, almost free from weight and bulk, may be stripped off. To print from these flimsy negatives, it is only necessary to place them on glass. When a flexible support shall have been introduced for the gelatine emulsion, the negative processes of photography will be almost perfect. With the collodion emulsion, we are able to get a physical condition of the bromide, in which it will answer to the vibration of the rays of the lowest refrangibility. Photographs of the solar spectrum taken on this salt were shown, corresponding to wave-lengths which lie more than three times as far below the red as the distance of the visible spectrum. This process is being applied to the examination of different colorless bodies, with a view of obtaining spectroscopic analyses of them. It has been discovered that the photographic image is rendered undevelopable by the action of oxidizing agents, and this alike whether it be produced on a collodion or a gelatine film or on paper. The oxidation of the image goes on also in ordinary atmospheric conditions, more especially under the influence of light, and in it we have a simple explanation of what is known as solarization. A platinum process, in which an image is produced in platinum-black, is about four times as sensitive as the ordinary silver process, and marks the greatest advance in printing that has been made for many years. Another printing process is based on the reduction, by ferrous oxalate, of bromide of silver which has been exposed to light, and was discovered almost simultaneously by Mr. Willis, of England, and Mr. Carey Lea, of Philadelphia. The prints obtained by this process have great permanence, since no organic compound of silver, the great agent of deterioration, is present in them. Mr. Lea has discovered within the last year that the power of development which is shared by most of the organic salts of ferrous oxide is not limited to them, but is possessed also by many of its inorganic compounds. He gives a brief account of his researches in this direction, and of the properties of the different salts of the oxide, in the "American Journal of Science" for June.

The Regulation of Visual Tests.—The Boston "Herald" published last summer a review of what had been done in the United States during the previous twelve months to secure protection against the dangers arising from color-blindness and visual defects in seamen, railroad-men, and other persons occupying positions of trust in which the quality of eyesight is important. Three departments of the national Government have adopted regulations on the subject. The War Department has ordered the examination of recruits by test-cards, to test their power of distinguishing objects at a distance, and with worsteds for their perception of colors. The Treasury Department has made the examination of all pilots, as to their ability to distinguish colors, compulsory, with the provision that "a second visual examination will not be required in any case." The Navy Department has ordered a similar examination for all persons in the navy, or who may hereafter enter it. The House Committee on Naval Affairs has reported favorably on a petition of Dr. B. Joy Jeffries and others for the enactment of a general law of control for the naval and merchant service, and for a representation of the United States in an International Congress to agree upon definite standards of color-tests, and has reported a

bill authorizing such representation, which will come up at the next session of Congress. One steamboat company and one railroad company have instituted a compulsory examination of all their men. The State of Connecticut has adopted a law for the examination of railroad-men, with the following requirements for a certificate in the first class (engineers, firemen, and brakemen): 1. Healthy eyes and eyelids without habitual congestion or inflammation; 2. Unobstructed visual field; 3. Normal visual acuteness; 4. Freedom from color-blindness; 5. Entire absence of cataract or other progressive disease of the eye. For second-class certificates (conductors, station-agents, switchmen, etc.) the first two conditions are the same, but in the third condition is required only "visual acuteness at least equal to three fifths without glasses and normal with glasses in one eye and at least one half in the other eye, with glasses," and in the fourth "freedom from color-blindness in one eye, and color-perception at least equal to three quarters in the other eye."

Form of the Lightning-Rod.—The subject of the proper form of lightning-conductors, long a disputed one among scientific men, has recently been experimentally investigated by Mr. W. H. Preece, with the result of confirming the position of Faraday, that the section of a rod is the essential element. The advocates of rods of large surface, such as ribbons, tubes, etc., among whom was the late Professor Henry, conclude, from the fact that static electricity resides upon the surface, that electricity of high tension, such as a lightning-discharge, is better conducted away by a large extent of surface. Mr. Preece stated that no direct experiments had, so far as he was aware, ever been made to settle the question, which was an important one, as the acceptance of the surface theory had led to the employment of unsightly and costly conductors, when a simple rod would answer all purposes. The experiments were made in the laboratory of Dr. Warren de la Rue, and had the advantage of his advice and assistance. In the first experiment copper conductors thirty feet in length, in the form of a solid rod, a thin tube, and ribbon, each of precisely the same mass, were used. The electricity was obtained from 3,240 chloride-of-silver cells, and accumulated in a condenser of a capacity of 42·8 micro-farads. The sudden discharge of this quantity of electricity produced results similar in character to lightning. It was capable of completely deflagrating 2½ inches of platinum wire of .0125 inch diameter, and of raising to different degrees of incandescence greater lengths. Such wire, affixed to a white card so as to record the effect, was used to measure the discharge after it had passed through the conductor. Each form of conductor gave exactly the same result in the deflagration and heating of the platinum, showing that different extents of surface had no effect. As it might be thought that, in copper conductors of such length as those used, differences in conductivity could not be readily detected, the experiments were repeated with lead conductors, the resistances of which were twelve times that of copper, with the same results. An experiment, to determine how closely variations in the discharge could be estimated, showed that a change of resistance of five per cent. could have been easily detected. Mr. Preece, therefore, concludes that no more effective lightning-conductor than a simple rod or wire rope can be devised.

The Phenomena of Thunderstorms.—In a recent lecture at Glasgow, Professor Tait reviewed the present state of our knowledge of thunderstorms, and pointed out the chief conditions upon which the phenomena seemed to depend. The different degrees of conductivity of the air to which the zigzag form of the flash is due he thought might be produced by local electrification, which would have the same effect as heat in rarefying the air and making it a better conductor. Sheet-lightning is probably the reflection of a flash of forked lightning, itself invisible to the observer. Summer lightning is, in some cases, of a similar character, but in others, when the sky is clear, it seems to be due to discharges taking place in an upper strata of the atmosphere, the thunder being inaudible both on account of the distance and its originating in an atmosphere of but small density. The discharge in the form of a luminous ball is of rare occurrence, and but little is known of

it. It is probably a natural form of Leyden jar very highly charged. The light of a flash, Professor Tait states, is of very much greater intensity than is commonly supposed, the apparent brightness being, on account of the exceeding small duration, less than one hundred thousandth part of what it would be if the lightning were permanent. This duration is not more than the millionth part of a second, and hence it is a mistake to suppose that you can see the direction in which the discharge is passing, whether from the clouds to the earth or from the earth to the clouds. Professor Tait insists upon the necessity of properly pointing and grounding lightning-rods to secure safety, and mentions several instances of the ignorance in this matter which seems to prevail among even well-educated people. In one case the point of the rod was actually covered with a glass insulator. The best ground connection is with the water-mains, but large masses of metal or other conductor in a moist soil answer when these are not at hand. Connection with a body of water inclosed in a masonry basin, such as a reservoir, is not a proper way of grounding the rod. A lightning-rod acts as a constant drain upon the charge in the clouds in its neighborhood, and when the rods are numerous over any area, as in a well-protected town, storm-clouds will pass over without any lightning-flashes taking place, though such form of discharge will occur before reaching the protected district and after passing it. The lecturer insisted that people should regard the use of rods as both a public and private duty. In regard to the sources of electricity in the atmosphere, Professor Tait has been led by experimental researches to infer that a separation of the opposite electricities occurs simply by the contact of particles of air and aqueous vapor, which, on the kinetic theory of gases, are in constant collision. In the same way zinc and copper become oppositely electrified when brought into contact. The precipitation of vapor-particles into cloud-particles and the agglomeration of these into rain-drops enormously increase the electrification, as the potential of a free charged sphere is proportional directly to the quantity of electricity on it and inversely to its radius. The separation of these highly charged particles of air and water is effected by gravity and the diffusion of gases which would cause the air-particles to escape from among the mass of precipitated vapor to the less highly electrified air above. Sir William Thomson has offered an explanation of the phenomena, based upon the fact that the lower air is usually negatively charged. Ascending currents carrying this air upward, the electricity, which was formerly spread out over a large area, may by convection become so much less diffused that it will be raised to a high enough potential to give a spark. However the electrification of the precipitated vapor occurs, there is no question about the fact that, clouds once formed, the particles are electrified. The solution of the problem of just how this is brought about must in all probability come through experiments made on a larger scale than any so far conducted in the laboratory.

Science in the Schools of France.—The modifications in the course of studies in the French public schools, recently decreed by the Superior Council, give to scientific teaching a more prominent place than has hitherto been allowed it, especially in the elementary classes. In the seventh class, the elements of the natural history of animals and plants are added to the history of soils and stones, and take the preference over it, as offering more interest to children and being of greater practical utility. In the sixth class, an hour is deducted from the ten devoted to Latin and added to those given to the sciences, which are allowed four hours a week. In the fifth class, where scientific instruction has been obviously deficient, the hours for Latin are reduced to five, and the sciences are given four hours. In the fourth class an hour is taken from Greek, and the hours for scientific instruction are increased to four. Scientific instruction will be continued in the third, second, and rhetorical classes without encroaching upon the other courses, an hour being taken from the study-hours for new subjects of natural history in the third class, for physics in the second class, and for subjects of physics which have not been previously entered upon by the pupils, in the rhetorical class. The Superior Council advises that the teach-

ing of mathematics and the natural sciences in the grammar-classes be committed to special professors whenever the funds of the school will permit it and suitable teachers can be obtained; otherwise, professors of science in the higher classes may perform the duty for an additional compensation; or, if there is no other way, the ordinary professor may provisionally give the special instruction.

M. Faye's Theory of the Crust of the Earth.—M. Faye has propounded a new theory of the internal structure of the earth, an important feature of which is that its solid crust is much thicker under the seas than under the continental masses. The oscillations of the pendulum and the direction of the plumb-line are known to be subject to variations in consequence of the neighborhood of a mountain, or even of a hill, calculations based upon which enabled Maskelyne to determine the density of the globe. When, however, experiments with the plumb-line and pendulum were applied to table-lands and to the grander mountain-ranges, the deviations corresponding to the magnitude of the masses which were expected were not shown. The pendulum which is sensitive to the presence of the Great Pyramid of Egypt gives no sign of the neighborhood of the Himalayas. Further than this, a real deficiency of attraction has been observed upon continents, as if there were a great hollow under them; and the failure of mountain-masses to deflect the pendulum has been actually attributed to the existence of cavities in them. On the other hand, when the investigation is transferred to the sea, the weight is found to be too great, and is in excess of what is demanded by theory, as evidently it falls short of it on the continents. Hence, if we suppose that there is a lack of matter under the continents, we must also suppose that there is under the seas an accumulation of it above the average for the whole earth. M. Faye suggests, to account for these contradictions, that the cooling of the earth is going on faster and has taken place to a greater depth under the oceans than under the continents. The temperature at 12,000 feet of depth below the sea is a little higher than the freezing-point; at the same depth under the continental masses it is computed to be about 300°. The matter is kept at this temperature by the superior strata of earth almost impermeable to heat, and through which the heat that actually escapes is hardly perceptible. The crust of the earth in such a situation can increase in thickness only at the slowest. Under the sea, on the other hand, matter at the same depth is in almost immediate communication with a cold of the freezing-point, and, instead of having some non-conducting strata above it to prevent its escape, the heat is immediately absorbed in a cold of polar intensity. A similar difference exists deep in the beds of the submarine rocks, for the water is imbibed in their pores to a greater depth than in the sub-continental rocks, and the heat is conveyed away from them by the vertical convection of the warmed water rising in them. The more ancient the existing beds of the sea, the greater is the thickness of the crust that supports them as compared with that of the continents.

Trichinosis on a British School-ship.—A remarkable outbreak of trichinosis on the British reformatory school-ship Cornwall has recently been brought to the notice of the Government health boards. Up to the 23d of September last, the health of the boys had for a long time been good, but, between that day and October 23d, forty-three boys were taken sick, falling ill in batches—seven on the 23d, two on the 24th of September, sixteen between the 29th of September and the 1st of October, nine between the 3d and 6th, and the rest at intervals. The outbreak was regarded as one of enteric fever, and the general character and progress of the disease seemed to justify the view. No cause, however, likely to produce such an outbreak could be discovered. The hygienic condition of the ship was perfect. The inspector turned his attention to the food, and found that none of the officers, who were supplied with distinct food from the boys, were attacked. The boys from a particular mess suffered more than the others, and the tendency of the groups of fresh cases to occur on certain days of the week suggested a connection between the attacks and the salt pork that was served out on Mondays. The body of

one of the boys who had died was examined, and the microscope showed living trichinæ in his muscles, but none of the appearances of enteric fever were discovered. A new cask of salt pork had been opened just before the disease appeared, the meat from which is supposed to have communicated the trichinæ to the boys. This view is confirmed by the fact that the disease ceased soon after the use of the pork was stopped. The method of cooking the meat on the vessel seems to have been defective and not sufficiently thorough to insure the heating of the whole mass to the temperature at which the trichinæ are destroyed.

Sensitive Organs of Deep-Sea Animals.—M. O. Grimm has sought to explain how it is that we find in the great depths of seas and lakes animals without eyes, and besides them others in which those organs are highly developed. According to his view, the light received by animals living in these depths is extremely feeble, but is never totally wanting. An adaptation to these special conditions has taken place. With certain crustaceans, the eyes have gained a considerable volume; with others, the eyes tend to disappear and to be replaced by other sensitive organs. In the Niphargus and Onesimus, for instance, the existence has been detected of extremely developed sensitive organs which may be supposed to serve as organs of touch, taste, and smell. *Niphargus Caspius* has very small eyes, which can hardly be considered as anything but the remains of normal organs, and can hardly be of any use to an animal living at a depth of from thirty-five to ninety fathoms, but it has highly developed organs of smell and touch on its antennæ. The Onesimus, whose eyes are also very rudimentary, have neither on the antennæ nor other parts of the body sensitive organs like those of the Niphargus, or at least such as they have are very little developed; but a close examination will discover, on the external blade of their foot-jaws (maxillipedes), well-constituted organs of sense, although they are hidden and of a very different structure from those of Niphargus. In explanation of this difference in the nature of the sensory organs of genera so nearly related to each other, M. Grimm remarks that the species he has found with organs of sense on their antennæ always live in the water and never go into the mud. The Onesimus, on the other hand, keep constantly in the mud of the bottom and seek their food by digging, as the moles do. Under such conditions, delicate organs of sense on the antennæ would be of no use, and have become nearly obliterated, while the situation has favored the development of organs in a protected position.

NOTES.

The next meeting of the French Association for the Advancement of the Sciences is to be held in the city of Algiers, on the 14th of April. The people and authorities of the city are busily making preparations to give the Association a worthy reception and welcome. Liberal appropriations have been made by the council for the material organization of the meeting, and a large committee of citizens, under the presidency of M. Pomell, Senator and Director of the Superior School of Sciences, is preparing a programme of excursions, which will be well filled out. M. Chauveau, Director of the Veterinary School at Lyons, will be president, M. Janssen, the astronomer, vice-president, and M. Maunoir, of the Geographical Society, secretary, of the meeting.

We have news of the recent death of Michel Chasles, the eminent French mathematician. M. Chasles was the author of an historical memoir on the origin and development of methods in geometry, and of numerous works in pure mathematics, and in 1865 received, in recognition of his discoveries, the Copley medal of the Royal Society.

The name of the author of the useful little work noticed in our last number, under the title "What to do first in Accidents or Poisoning," is Charles W. Dulles, not Dallas, as it was there erroneously printed.

The death is announced of Dr. John Stenhouse, F. R. S., a distinguished Scotch chemist, at the age of seventy-one. He was a pupil of Graham, Thomson, and Liebig, held the chemical lectureship at the Medical School of St. Bartholomew's Hospital, London, for six years, and was subsequently appointed non-resident Assayer of the Royal Mint. He wrote a large number of papers on chemical subjects, and was the recipient of a medal from the Royal Society, of which he was long a member.

According to the researches of Gustav Hausen, the antennæ of insects are organs

of smell. He found that, on their removal or when coated with paraffine, the insects became quite indifferent to the most odorous substances—flies, for example, when thus treated, taking no further notice of tainted meat.

Professor Ernst Hampe, the distinguished German bryologist, died at Helmstedt, November 23d, at the age of eighty-five.

The "Revue Scientifique" acknowledges that the meetings of the French Association and the British Association will have to yield place, for 1880, to that of the American Association for the Advancement of Science, which excelled on account of the importance of the subjects discussed, and was also marked by a numerous attendance and the manifestation of a great interest in its proceedings.

An International Congress of Electricians has been called by the French Government, to meet in Paris on the 15th of September, 1881; and an International Exposition of Electricity is to be opened on the 1st of August and to be closed on the 15th of November. The Government leaves the expenses of the Exposition to be paid by those who participate in it, but it is believed that the whole financial responsibility of the affair will be assumed by a French capitalist. The preparations for the Congress and the Exposition will be under the direction of M. Georges Berger.

The notion that the blood-capillaries receive material support from the tissues in which they are imbedded is contradicted by the researches of Ray and Brown, an account of which is published in a late number of the "Journal of Physiology." According to their experiments, the extra-vascular pressure is but slightly, if any, greater than that of the atmosphere; that is, if the surrounding tissues were all removed, the capillary walls would be no more likely to give way from internal blood-pressure than they are under normal conditions.

Professor J. C. Watson, Director of the Observatory at the University of Wisconsin, died on the 23d of November of last year. He had acquired a high reputation as an astronomer, both here and at the University of Michigan, where he was formerly engaged, and was best known, perhaps, by his discoveries of twenty-one of the asteroids, by his work in the observation of the transit of Venus, and the solar eclipse of 1878, and by the interest he took in the search for the supposed planet Vulcan.

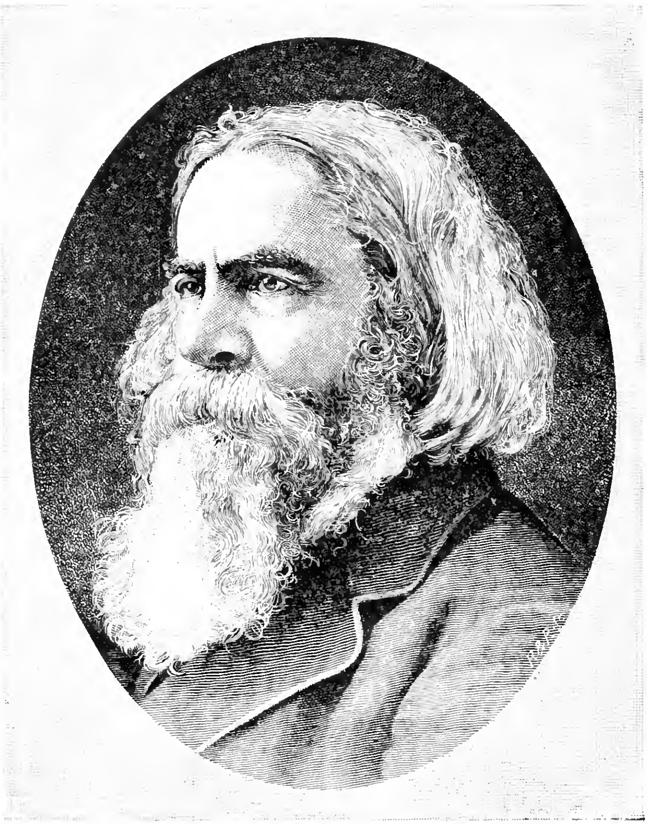
The equipment of the observatory now in course of construction at Nice will comprise two equatorials, one meridian, and several accessory instruments. One of the equatorials will probably be the largest astronomical apparatus in the world. Its focal distance will be about sixty feet, and its aperture thirty inches. The cupola will have a diameter of seventy-two feet. The object-glass is to be constructed by MM. Paul and Prosper Henry, of the Paris Observatory. The instrument alone will cost 250,000 francs, and the entire observatory at least 2,000,000 francs.

Professor Alphonso Wood, author of several works on botany, died at West Farms, New York, January 4th, aged seventy-one years. He was a graduate of Dartmouth College and Andover Theological Seminary, and spent much of his life as a teacher, having had the charge of schools at Meriden, Connecticut; College Hill, Ohio; Terre Haute, Indiana; and Brooklyn, New York. For the last two years he was Professor of Botany in the College of Pharmacy in this city. He began the publication of his botanical writings in 1860. His best-known works were: "The Class-Book of Botany," "Object-Lessons in Botany," "The Botanist and Florist" "The Plant Record," and "Flora Atlantica."

A new process of tanning, in which bark is wholly dispensed with, and inorganic compounds are used in its place, is coming into use in Germany. The special feature of the process is the action of chromic acid, for the generation of which a number of substances, all soluble in water, are brought together in the mixture so as to effect the decomposition of bichromate of potash. The new process requires only from four to six weeks for its completion, against the several months needed in the bark-process. It has been tried at an experimental tannery in Glasgow, Scotland, with favorable results.

Benjamin Collins Brodie the younger, F. R. S., died on the 24th of November last. After taking his master's degree at Oxford in 1842, he went to Giessen to pursue original chemical work under Liebig and first distinguished himself by the publication of his analyses of wax. He became an industrious investigator of the changes undergone by the molecules of different substances, and of the modes of combination, and had an important part in the development of the present theories of chemistry.

Père Antoine Horner, the founder of the French Roman Catholic mission and agricultural establishment at Bagamoyo on the Zanzibar coast, has recently died at Cannes. He made long journeys of exploration in the interior of Eastern Africa, in recognition of the scientific results of which he was elected an honorary corresponding member of the Royal and several other geographical societies.



BENJAMIN PEIRCE.

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PHYSICAL EDUCATION

By FELIX L. OSWALD, M. D.

IN-DOOR LIFE.

"What is to the mind a healthy body,
To the body is a healthy house."
—Fabio Colonna.

Next to our dietetic sins, the abuses connected with our habits of domestic life have contributed the largest share to the great sum of human misery. Yet few evils might be more easily avoided. There are diseases which may be considered as visitations of national iniquities whose consequences are almost beyond the control of individuals; but for the sufferings caused by scrofula and pulmonary disorders we are indebted chiefly to our own prejudices. Prejudice and ignorance have filled more consumptives' graves than poverty. Even in large manufacturing towns air is free. If our artisans could realize the consequences of breathing miasma, they would prefer the life-air of the wildest wilderness to the lung-poison of their slums; like a caged bird, the tenement prisoner would refuse to pair rather than people the earth with cachectic wretches. The exodus of their workmen would soon induce manufacturers to imitate the founder of Saltaire; building speculators would find it to their advantage to adopt the Philadelphia plan, adding suburb to suburb rather than loft to loft; cities would grow outward instead of upward. A reform of that sort would imply various modifications of our present labor system; but before the enlightenment of public opinion such difficulties vanish like mist before the rising sun. There was a time when it was actually proposed to abolish the summer vacations of the French town schools "in order to enlarge their curriculum in proportion to the advance of modern

science"; but, since we have ascertained that out-door exercise is more important than all the graphies and ologies of the Académie Française, it has been found that, with a well-arranged plan of instruction ten months a year, five days a week and six hours a day are quite enough for any school. If the eight-hour system were generally adopted, operatives would not be compelled to live within ear-shot of the factory-whistle, and in very large cities the daily influx and reflux of a suburban multitude would enable railroad companies to carry individuals at rates which the poorest would call moderate. Far enough from the city center to evade the region of dear building-lots, and yet within easy reach of all kinds of door and sash factories and planing-mills, there would be no need of crowding three generations into a single room, and suffocating them with mingled kitchen-fumes and sick-bed odors. Three rooms and an out-house should be the minimum for a family with children.

In a tolerable location, the air of a three-room cottage can be kept pure enough without force ventilators or any other expensive contrivance. Open your windows; in very cold weather, air the bedrooms in daytime and the others at night. In larger houses, the kitchen, parlor, and dining-room should be thoroughly ventilated every night, also in daytime at convenient intervals, during the temporary absence of the occupants. To save foul air for the sake of its warmth is poor economy; experiments would show that the difference in fuel amounts only to a trifle, anyhow. Ten or twelve pounds of coal a day ought not to weigh against the direct gain in comfort and the prospective, unspeakable gain in health. Breathing the same air over and over again means to feed the organism on the excretions of our own lungs, on air surcharged with noxious gases and almost depleted of the life-sustaining principle. Azotized air affects the lungs as the substitution of excrements for nourishing food would affect our digestive organs: corruption sets in; pulmonary phthisis is, in fact, a process of putrefaction.

No ventilatory contrivance can compare with the simple plan of opening a window; in wet nights a "rain-shutter" (a blind with large, overlapping bars) will keep a room both airy and dry. In every bedroom, one of the upper windows should be kept open night and day, except in storms, accompanied with rain or with a degree of cold exceeding 10° Fahr. In warm summer nights open every window in the house and every door connecting the bedroom with the adjoining apartments. Create a thorough draught. Before we can hope to fight consumption with any chance of success, we have to get rid of the *night-air superstition*. Like the dread of cold water, raw fruit, etc., it is founded on that mistrust of our instincts which we owe to our anti-natural religion. It is probably the most prolific single cause of impaired health, even among the civilized nations of our enlightened age, though its absurdity rivals the grossest delusions of the witchcraft era. The subjection of holy reason to hearsays could hardly go further.

"Beware of the night-wind; be sure and close your windows after dark"! In other words, beware of God's free air; be sure and infect your lungs with the stagnant, azotized, and offensive atmosphere of your bedroom. In other words, beware of the rock spring; stick to sewerage. Is night-air injurious? Is there a single tenable pretext for such an idea? Since the day of creation that air has been breathed with impunity by millions of different animals—tender, delicate creatures, some of them—fawns, lambs, and young birds. The moist night-air of the tropical forests is breathed with impunity by our next relatives, the anthropoid apes—the same apes that soon perish with consumption in the close though generally well-warmed atmosphere of our northern menageries. Thousands of soldiers, hunters, and lumbermen sleep every night in tents and open sheds without the least injurious consequences; men in the last stage of consumption have recovered by adopting a semi-savage mode of life, and camping out-doors in all but the stormiest nights. Is it the draught you fear, or the contrast of temperature? Blacksmiths and railroad-conductors seem to thrive under such influences. Draught? Have you never seen boys skating in the teeth of a snow-storm at the rate of fifteen miles an hour? "They counteract the effect of the cold air by vigorous exercise." Is there no other way of keeping warm? Does the north wind damage the fine lady sitting motionless in her sleigh, or the pilot and helmsman of a storm-tossed vessel? It can not be the *inclemency* of the open air, for, even in sweltering summer nights, the sweet south wind, blessed by all creatures that draw the breath of life, brings no relief to the victim of aërophobia. There is no doubt that families who have freed themselves from the curse of that superstition can live out and out healthier in the heart of a great city than its slaves on the airiest highland of the southern Apennines.

In such countries as Italy and Mexico, where the plurality of the population pass the daylight hours in open air, unventilated bedrooms are almost the only cause of tubercular diseases; but in the north, where children have to be nursed like exotic birds, the chief defects of our domestic arrangements may be classed under three heads: impure air, want of sunshine, and want of room for exercise. The *beau-idéal* of a healthy house would be a well-plastered stone building on some eminence, remote from swamps and stagnant creeks, but surrounded by sunny slopes available for play-grounds; spring or well water; outdoor cellar, kitchen in an out-house, or at least not directly below the sitting and sleeping rooms; high ceilings, wainscots, or wall-paper of innocuous colors; deep windows, with projecting mullions to admit the air and exclude the rain; an airy veranda, and no shade-trees on the east and west side, as sunlight is most needed in the mornings and evenings. Children can not thrive in dark back rooms, and in the first eight years of their lives should have all the exercise they want. The countrymen of Dr. Fröbel are ahead in this respect, and the best-ar-

ranged nursery I ever saw was the *Findel-zimmer* ("foundling-ward") in the convent of the Ursuline nuns near Würzburg, Germany. The landed estate of the convent having been sequestrated, their department of charitable institutions had been reorganized on a more economical basis, and the poor nuns thought it necessary to apologize for the ingenious simplicity of their Zimmer, whose plan had been suggested chiefly by the necessity of dispensing with hired help. The room was about forty feet square, facing south and west, with three large windows on each side. These windows and the fireplace were barred with net screens, soft to the touch, but securely fastened, and strong enough to stop anything from a football to a forty-pound baby. The floor was carpeted with rugs, covered with a sort of coarse sheeting to prevent dust. From the floor to the height of the window-sills the walls were padded all round with old blankets, secured with muffled nails, and stuffed with something that felt like moss or cow's hair. The only piece of furniture was a cushioned divan in the corner next to the fireplace; but the floor was covered with playthings and movable nondescripts, balls of all sizes, and a big *Walze*, a sort of wooden cylinder, muffled up with quilts and cotton. From the center of the ceiling depended a hand-swing, two rings just low enough to be within reach of a youngster standing on tiptoe, the original sitting swing having been removed as liable to be used as a catapult in a general row. Above the windows, out of reach of the boldest climber, were shelves with flower-pots, reseda, gillyflowers, and wintergreen. In this in-door Kindergarten, fourteen playmates—twelve babies, namely, and two puppies—had been turned loose, and seemed to celebrate existence as a perpetual circus-game. They could run races, pelt each other with cotton balls, swing in a circle, roll on the floor, and ride the Walze; but the attempt to hurt themselves would have baffled their combined ingenuity. There were no nurslings, of course, but all mischief-ages from three to eleven, wrestling and quarreling now and then, but, as the nuns solemnly averred, never crying except for causes that would make the puppies cry—a squeeze or an inadvertent kick—all disputes being referred to the umpire, a flaxen-haired girl of eight, who often took charge of the Zimmer from morning till night.

The squalling of new-born children can not be helped; puppies will whine, and young monkeys whimper for the first three or four days—it is the novelty of existence that bewilders them—but, if babies of two or three years scream violently for hours together, it generally means that there is something wrong about the management. Indian babies never cry; they are neither swaddled nor cradled, but crawl around freely, and sleep in the dry grass or on the fur-covered floor of the wigwam. Continual rocking would make the toughest sailor seasick. Tight swaddling is downright torture; it would try the patience of a Stoic to keep all his limbs in a constrained position for such a length of time; a young ape subjected to the same treatment would

scream from morning till night. Forty per cent. of all children born in certain manufacturing districts of Belgium and Great Britain die before the end of the second year. They are swaddled, of course; they must not crawl around, and bother people; and "paregoric" does the rest: the child cries for liberty, and receives death. Opiates are sold under right pleasant names nowadays, and at popular prices in the larger cities; but a spoonful of arsenic would be a shorter and a kinder remedy.

Not every family has room and the means to construct a model nursery, but the poorest could spare a few square feet of space in some sunny corner, and, with old quilts and rugs, make it baby-proof enough for all probable emergencies. Then furnish a few playthings and trust the rest to nature. Man wants but little here below, and between meals a pickaninny will content itself with liberty, light and air, and a couple of rag-babies. As soon as a child begins to toddle, it should also have an opportunity to exercise its arms—a grapple-swing, or (if your ceiling be inviolate) a rope stretched from wall to wall. It is surprising how fast the clumsiest youngster begins to profit by such a chance. To the young son of man climbing comes natural enough to shock a witness of anti-Darwinian proclivities. The development of the shoulder-muscles also tends to invigorate the chest, and a fifty-cent hand-swing may save many dollars' worth of cough-medicine.

The progressive development of the motory organs prompts their frequent exercise, and there is no doubt that the gratification of this instinct constitutes the chief element of that physical beatitude which makes the age of childhood the spring-time of every life; and it is equally certain that compulsive physical inactivity inflicts on a healthy child an amount of wretchedness which no prospective advantages can possibly repay. It is hard enough that so large a portion of the human race have to rear their young in a latitude which half the year confines them to the freedom of their four walls; but it is harder that even this limited freedom should be curtailed by so many unnecessary restraints. I wish every houseful of children had a rough-and-tumble room, some out-of-the-way place where the cadets could romp, roll, and jump to their hearts' content. It need not be a heated room nor even an in-door place, as long as it has anything like a roof to it; children are naturally hardy, as they are naturally truthful: effeminacy and hypocrisy are twin daughters of our pious civilization. A wood-shed will do, or a lumber-room with old mattresses and hiding-places. Well-to-do parents might add some gymnastic apparatus, and for big boys a carpenter's table with an assortment of tools; mechanical dexterity may prove useful in many ways, and every normal boy has something of that instinct which phrenologists call *constructiveness*, and which makes the use of such implements a pleasure rather than a task. But, for the youngsters, the rough-and-tumble play is the main thing; it will strengthen their limbs, lungs, and livers, and

prevent more ailments than all the pills in Herrick's list of patent medicines. Moreover, it will keep them quiet where other children are sure to be fidgety—in the parlor and at school. Every school-teacher knows that young ruralists are more sedate than city boys ; out-door work has given them all the exercise they need ; they can take it easy while their comrades are fretting under an irksome restraint. After an hour or two of German gymnastics, combined wtth wood-chopping and water-carrying, if you like, the wildest boy will prefer a chair to a flying trapeze ; for, if the tonic development of the organism is not grossly neglected, sedentary employments *per se* are by no means contrary to nature ; in the intervals of their play, the young of frolicsome animals will sit motionless for hours ; even kittens and young monkeys ; not to mention colts which have off-days, when they won't stir a foot if they can help it.

It would be a great improvement on our present system of school-education, if children could learn the rudiments at home and pass their infancy, the first eight or ten years, at least, under the immediate supervision of their parents ; a transition-period of three or four years of home studies would help them to steer clear of many moral and physiological cliffs. It is always the best preparatory school ; only a private teacher has time and patience to *interest* a pupil in the dry *principia* of every science ; but a still greater advantage is his independence of fixed methods and fixed hours. As a general rule, the forenoon is the best time for studies, and the airiest room in the house the best locality. Pure air has a wonderful effect on the clearness of our cerebral functions ; the half-suffocating atmosphere of the average schoolroom is as stupefying as the influence of a half-intoxicating drink. Heat aggravates the offensiveness of foul air ; but in a well-ventilated room the degree of temperature is comparatively unimportant. As it would be inconvenient to load ourselves with blankets in daytime, less than 50° Fahr. would make sedentary occupations rather uncomfortable, and more than 80° would become oppressive in a close apartment ; but between these extremes we may safely suit our convenience. Perfectly pure or perfumed air may be very warm and still very pleasant, as all know who have entered a conservatory or a tidy baker's shop on a cold winter day.

In large town schools, where hundreds of children have to breathe the same air, I would advise a change of rooms from hour to hour, and a thorough renovation of the vitiated atmosphere by opening every window and every door, and keeping up a rousing fire. The air-currents could be reënforced by mechanical means—canvas-floppers or revolving fans—and *fumigation* would greatly aid the good work. The South European druggists sell various kinds of frankincense that can be burned on a pan or a common stove, and will fill a large church with odors more or less Sabæan, according to price—ten cents' worth a day would be enough to beatify a whole town school ; Mohammed, the

man of God, included perfume among the three greatest blessings of human life. Young children ought to have a recess after every lesson, and should not be required to sit rigidly quiet. The best writing-stand for children is Schreber's "telescope-desk," a box-like contrivance, with a movable top that can be lowered or raised to suit the convenience of sitting or standing writers. In a latitude where the weather so often precludes the possibility of out-door recreations, every schoolhouse should have a recess-room, and every town school an in-door gymnasium.

Fireside comforts are almost inseparable from the idea of an open fireplace, and from an hygienic standpoint, too, the old-fashioned chimney, or an open grate, is far superior to a closed stove. But it should not be forgotten that the operation of the chimney-draught alone is insufficient to correct the vitiated air of a small room, it merely creates an outward current. An open window completes the renovating process ; in cold weather a few minutes are sufficient to revitalize the in-door atmosphere for a couple of hours. Only the blindest prejudice can deny the pleasant effect of such an influx of life-air ; it revives the azotized lungs as a draught of cool water refreshes the parched palate. Colds are never taken in *that* way. The very name is a misleading misnomer—*infection* or influenza would be the right word. Long exposure to a freezing storm, in certain cases, induces a true pleuritic fever, a very rare affection, and entirely different from the only too familiar catarrh. What we call a *cold* (*refroidissement*, *Erkältung*) is caused by the influence of impure air, or dust, on the sensitive tissue of our respiratory organs ; subsequent exposure to the open air merely initiates the crisis of the disorder, the discharge of the accumulated mucus through the nose or throat. Fresh air is here only the proximate cause, as in toothache, or in those paroxysms of retching following upon the first respiration of a half-drowned person. If we postpone the crisis by persistently avoiding the open air, the unrespirable matter, instead of being discharged, will be deposited in the tissue of the lungs in the form of tubercles.

In the chapter on Diet I have stated the physiological objections to a late supper, and I will here mention an additional reason why the afternoon meal should be the last : It would give an overworked mother a chance to close the kitchen-door at six o'clock, and devote the rest of the evening to her family. Domestic habits depend greatly upon the employment of the long winter evenings that have to be passed in-doors somewhere ; whether at home or—elsewhere, depends upon home-comforts rather than upon home-missions ; a treatise on the art of making the chimney-corner attractive would be the most effective temperance lecture. Fredrika Bremer recommends fairy stories ; in a North American city Scheherezade would probably avail herself of the circulating library, and a fascinating story-book is, indeed, an excellent substitute for the old-fashioned remedies against gadding. Good

books, flowers, and music, combined with pleasant conversation and a cheerful fire, would neutralize the attractions of the average "saloon." Playthings and social games, too, would help to compensate the youngsters for the want of out-of-door sports, and where they have a room to themselves I would suggest the introduction of some entertaining pet, a raccoon or a tame squirrel-monkey. Let the boys have some fun—provide pastimes; it is *ennui* rather than natural perversity that leads our young men to the rum-shop.

The end of the day is the best time for a sponge-bath; a sponge and a coarse towel have often cured insomnia where diacodium failed. A bucketful of tepid water will do for ordinary purposes; daily cold shower-baths in winter-time are as preposterous as hot drinks in the dog-days. Russian baths and ice-water cures owe their repute to the same popular delusion that ascribes miraculous virtues to nauseating drugs—the mistrust of our natural instincts, culminating in the idea that all natural things must be injurious to man, and that the efficacy of a remedy depends on the degree of its repulsiveness. Ninety-nine boys in a hundred would rather take the bitterest medicine than a cold bath in mid-winter. If we leave children and animals to the guidance of their instincts they will become amphibious in the dog-days, and quench their thirst at the coldest spring without fear of injurious consequences; but in winter-time even wild beasts avoid immersion with an instinctive dread. A Canadian bear will make a wide circuit, or pick his way over the floes rather than swim a lake in cold weather. Baptist missionaries do not report many revivals before June. Warm springs, on the other hand, attract all the birds and beasts that stay with us in winter-time; the hot spas of Rockport, Arkansas, are visited nightly by raccoons and foxes in spite of all torchlight hunts; and Haxthausen tells us that in hard winters the thermæ of Paetigorsk, in the eastern Caucasus, attract deer and wild-hogs from the distant Terek Valley. I know the claims of the hydropathic school, and the arguments *pro* and *con*, but the main points of the controversy still hinge upon the issue between Nature's testimony and Dr. Priessnitz's.

Our beds are our night-clothes, and ought to be kept as clean as our shirts and coats. Woolen blankets are healthier than quilts; put a heavy United States army blanket over a kettle full of hot water and see how fast the steam makes its way through the weft; a quilt would stop it like an iron lid, and thus tends to check the exhalation of the human body. In order to disinfect a quilt you have first to loosen the pressed cotton; a woolen blanket can be steamed and dried in a couple of hours. For similar reasons a straw tick is better than a horsehair mattress, though a woven-wire mattress is perhaps preferable to both. Feather-beds are a recognized nuisance. Children over ten years should sleep alone, or at least under separate blankets, if the bedsteads do not reach around.

If you would preserve your children from wasting diseases, do not stint them in their sleep ; chlorotic girls, especially, and weakly babies need all the rest they can get. If they are drowsy in the morning, let them sleep ; it will do them more good than stimulants and tonic sirups. For school-children in their teens, eight hours of quiet sleep is generally enough, but do not restrict them to fixed hours ; in midsummer there should be a *siesta*-corner in every house, a lounge or an old mattress in the coolest nook of the hall, or a hammock in the shade of the porch, where the little ones can pass the sleep-inviting afternoons. Nor is it necessary to send them to bed at the very time when all nature awakens from the torpid influence of the day-star ; sleep in the atmosphere of a stifling bedroom would bring no rest and no pleasant dreams. But an hour after sunset there will be a change ; the night-wind rises and the fainting land revives ; cool air is a febrifuge and Nature's remedy for the dyspeptic influences of a sultry day. Open every window, and let your children share the luxury of the last evening hour ; after breathing the fresh night-air for a while, they will sleep in peace.

THE PROBLEM OF MUNICIPAL NUISANCES.

By ROGER S. TRACY, M. D.

THE general democratic tendency of the past three hundred years has had some curious results. Free thought and free speech have brought about a universal freedom in criticism, so that, at the present time, singularly enough, it has come to be looked upon as a sign of high civilization and progress for every man to have an opinion about everything, whether he knows anything about it or not. One of the most complicated political problems that men have ever had to treat, viz., the Eastern question, is discussed in this city, by individuals and newspapers, with more readiness and assurance than in the council-chambers of Berlin or London, and every man above the condition of a rag-picker will give you his opinion on the philosophy of evolution. This exaggerated sense of self-importance brings with it not only the tendency to criticise everything not in accordance with each person's notion of what is right or expedient, but, inasmuch as conflicting currents of thought and action are unavoidable, a profound feeling of dissatisfaction with one's own environment. This feeling of dissatisfaction shows itself in curious ways. In place of the intense patriotism and personal loyalty of past ages, we find a widespread belief in almost all highly civilized nations that things are better managed elsewhere than at home, and the newspapers, here and abroad, are crowded with this not-always-well-based self-criticism. New York newspapers are

great sinners in this respect. While they are continually extolling the natural advantages of the city, her magnificent river-front and harbor, her advantageous situation, her brilliant sky, they are also constantly bewailing her bad government, her lukewarm public spirit, and the universally asinine quality of her public officers. One would think that her present position as a metropolis is entirely due to natural advantages, and has been gained in spite of the most earnest opposition from her leading citizens. The elevation of an honest, sober, intelligent citizen to a public office makes him straightway an ass in the estimation of his fellows. A public officer, who declines to do what certain citizens want him to do, is believed by them to be *prima facie* corrupt. If he agrees to do what they wish, some other citizens are equally certain that he has been bought. It seems impossible for a man to remain in public office in New York City for six months without having charges or intimations of bribery come to his ears, in one form or another. And not only are our public officers all supposed to be open to corrupt influences, but, when they are put in office, they are believed *ipso facto* to become suddenly ignorant of all that they knew before. And not only are they taunted with ignorance, incapacity, and an itching palm, but they are continually reminded that things are much better managed elsewhere, and that the sooner they learn how a city ought to be governed, by observing how other cities are governed, the sooner they will become of some use in their places.

One of the things New-Yorkers complain most about is the dirty streets, including the garbage-box nuisance. It is a popular belief, fostered by the leading newspapers, that New York is the only large city in the civilized world where such a filthy nuisance as the garbage-box would be tolerated, and those officers who have charge of the public health are continually reminded of Paris and London, where no such frightful eyesores exist, and where the public service in this regard is immaculate, as every person who has taken a flying summer trip through those cities is ready to testify.

Another frequent cause of complaint is the offensive odors from manufacturing establishments, which also are believed to be kept under such strict watch in Paris and London that they are never nuisances; and the American visitor, being sure that such things are banished from those cities, wants to have them driven out of this one.

The purpose of this paper is not to show that the complaints of our citizens are unfounded, for they are, unfortunately, too well founded, but to do something toward stemming the prevailing current of opinion —1. That the dirty streets and offensive odors of New York are entirely due to the negligence, stupidity, or corruption of public officers; and, 2. That Paris and London are free from the same kind of nuisances. I shall, in other words, try to show that Paris and London, in similar circumstances, are troubled with dirty streets and offensive odors, depending upon the same causes as in New York, and that the public

officers of those cities find precisely the same difficulties in abating such nuisances that are met with here; and I submit that the public officers of the city of New York ought not to be called or considered stupid, ignorant, or corrupt, because they meet with the same difficulties as the intelligent, honest, and trained public officers of Paris and London, and, like them, do not always succeed in surmounting them to the satisfaction of the public.

This is not the place for a complete discussion of the subject of street-cleaning, but it may be well, as a preliminary to what follows, to call attention to some points on which there is decided popular misapprehension. It is believed by most citizens of New York that ample funds are given to the Bureau of Street-Cleaning, and that, if this money were honestly expended, our streets ought to be as clean as those of Paris. Now, the facts of the case are these:

Our Bureau of Street-Cleaning employs 387 street-sweepers. Paris has a permanent corps of 3,180, besides 190 machines, each doing the work of ten men. Our bureau has to clean, more or less perfectly, 1,415 acres of paved street surface; Paris, 2,667 acres. The great difference in force, in proportion to the work to be done, is apparent at a glance. Our sweepers are paid $1.60 per day for eight hours' work. The Paris sweepers receive sixty cents per day for ten hours' work. For the sake of ease in calculation, we will suppose that as much work is done here in eight hours as in Paris in ten hours. Then each sweeper in New York costs a dollar a day more than each one in Paris. From the figures already given, the following results may be deduced:

If New York sweepers received Paris wages, we should, with our present force, save yearly $141,255.

If New York sweepers received Paris wages, we could, without increasing the expense of street-cleaning, increase the force by 645 men, i. e., nearly treble it.

If there were as many sweepers in New York as in Paris, in proportion to the area required to be cleaned, the expense of street-cleaning in New York would be increased by $474,500.

If Paris sweepers received New York wages, the expense of street-cleaning in Paris would be increased by $1,160,700.

As a matter of fact, the expense of street-cleaning in New York for 1879 was $690,000, including $40,000 for removing ice and snow; and in Paris for 1878, $817,000, including $181,000 for the removal of ice and snow.

An important part of the duties of a street-cleaning bureau is the removal of ashes and garbage. It is also exceedingly difficult, in a large city, to do this effectively and economically. I say, in a large city, for in a small village the garbage nuisance is at its minimum, and it increases with the number and crowding of inhabitants. It is unfair to compare the New York method of removing ashes and garbage with that of smaller and less compact towns, like Boston and

Philadelphia. The difficulties to be surmounted in this city are even greater than in Paris or London, because of the peculiar shape of the city, and because we are surrounded by water. But this is a digression.

It is a common belief, reiterated in the daily journals, that the household and street refuse of Paris is sold for enormous amounts, and that so much money is received on this account that the street-cleaning service of that city is a source of revenue instead of expense. This is not so. The chief revenue in this regard is derived from the rag-pickers. In New York these people ransack the boxes and barrels on the street, without paying for the privilege, and all that they collect brings them a clear profit. In Paris, on the other hand, the privilege of rummaging the dust-heaps is farmed out to wealthy contractors, who employ about 7,000 *chiffoniers*, and have a monopoly of rag-picking. So far as I can ascertain, this is the only source of actual revenue to the city of Paris from its street refuse, and what the amount of this revenue is I can not learn. It is very hard to find out anything about the municipal expenditures of that city, as it has no official journal like our "City Record."

Now, let us see what are the practical results of the methods of street-cleaning and removal of household refuse adopted in Paris :

"Street-cleaning in cities has for its aim the removal of dust, mud, snow, filth, and household refuse. As regards the latter, which ought to be thrown directly into the carts, municipal regulations in Paris continually conflict with a corporation very jealous of its privileges ; I refer to that of the rag-pickers, who conduct a business represented by nearly 7,000 persons, collecting with their hooks material worth 4,000,000 francs ($800,000) a year, and feeding the manufactories of paper, pasteboard, lampblack, etc. We are obliged, therefore, to yield to the demands of these Diogenes of the street, and to allow, to the great prejudice of sight, smell, and health, the throwing upon the public street, toward evening, of all kinds of refuse, to be picked over by the hook of the rag-picker. They insist upon this, and they wield a great power."—(Fonssagrives, "Hygiène et Assainissement des Villes," Paris, 1874, p. 174.)

"In Freycinet's opinion ('Assainissement des Villes,' p. 343), as far as promptness and completeness of street-cleaning in the narrower sense are concerned, Paris is in advance of all other great cities ; but it is not so with the household refuse, which, in the absence of special means of removal, must naturally take its way over the street. Although this refuse, intended for removal and thrown on the street for this purpose, *ought to be taken away at an early hour of the morning, it often remains upon the street till evening, is scattered about, etc.*, and all, according to Freycinet, because they do not wish to interfere with the unhealthy occupation of the rag-pickers, who rummage the mess for rags and bones."—(Götel, "Oeffentl. Gesundheitspfl. in den Ausserdeutschen Staaten," Leipsic, 1878, p. 205. The italics are mine.)

Götel states that things are much better managed in Lyons and Bordeaux in this respect—very much smaller cities, be it noted.

So it appears that the problem of the expeditious and inoffensive removal of household refuse has not yet been solved in Paris, the opinion of amateur sanitarians in this country to the contrary notwithstanding.

Last December there were two heavy snow-falls in Paris, only four days apart. The first storm crippled the street-cleaning department, and after the second the authorities were almost in despair, being hampered, as ours are, by the lack of funds, and, while their hands were tied, being harassed, howled at, and snapped at by the journalistic jackals. Almost a complete history of this episode can be gathered from the following comments of the press:

"As regards locomotion, the streets are gradually becoming more practicable for both riding and walking, thanks to the army of sweepers that the municipal authorities have at length set to work. It is remarked, however, that on the occasion of the last heavy fall of snow in Paris, some five or six years ago, the public thoroughfares were cleared much more rapidly than this time, owing to the military having been engaged in the task, and some surprise is expressed that they were not made use of this year. Certain it is that the public have had to suffer much loss and inconvenience, which they might have been spared by more prompt and energetic measures on the part of the authorities."—(London "Standard" Paris correspondent, December 8, 1879.)

"In some of the public gardens the snow is untouched, and they have ceased to be thoroughfares; but in the streets it is slowly being carted away, the traffic being carried on under great difficulties. Most of the tramways have stopped working."—(London "Times" Paris correspondent, December 10, 1879.)

The depth of snow that fell in these storms was estimated to be fifty centimetres (twenty inches). The chief of the Department of Public Works, M. Alphand, being called upon to explain why he did not immediately remove it all, stated that there had fallen altogether about 7,000,000 cubic metres of snow, and that it cost three francs a cubic metre to remove it, or 21,000,000 francs for the whole (about $4,000,000). The Municipal Council did not feel authorized to expend this vast sum, but they did generously vote 500,000 francs ($100,000), in addition to the regular appropriation for street-cleaning, and M. Alphand was thus enabled to put an immense force at work upon the streets.

It is worthy of notice how differently this public officer was treated from our own. In the spring of 1879 our Police Commissioners were summoned before the Mayor, and two of them removed from office because they had not kept the streets clean during the winter. No extra appropriation for them—nothing but disgrace! A comparison of the condition of the streets in both cities may be instructive. In

Paris twenty inches of snow fell in December, eight inches at one time and twelve at another. And this was a remarkable event in that city, although such storms are not uncommon here. For instance: on February 3, 1876, we had eleven inches of snow; on January 13, 1877, thirteen inches; and March 16th following, three and a half inches. In the winter which proved so unfortunate for our public officers, we had, on January 1, 1879, five inches of snow, and on the 16th thirteen inches more, or eighteen inches in all, and nearly as much as fell in Paris last winter. Between these storms we had freezing weather, the thermometer marking above the freezing-point only six times, and never rising above 38° in the hottest part of the day. So the cases are not altogether dissimilar. Let us see how much better the efficient street-cleaning department of Paris did its work than ours.

The following extracts are from the "Figaro" of December 10, 1879:

"'La Presse' says, 'A little less politics, and a little more sweeping.'

"'Le Mot d'Ordre': 'A little more sweeping! "La Presse" is right; let them sweep out the head of the bureau.'

"'La Presse': 'We have lived in countries where snow is not an exception, as it is in Paris. In those places snow has never been an obstacle in getting about the streets. As soon as the snow begins to fall, they sweep it up and carry it away.'"

And "Figaro" adds: "All this is perfectly true; in London, they melt the snow instantly with jets of steam; in Berlin, where it snows almost constantly in winter, the street-cars do not cease running for an instant, owing to analogous measures, which keep the rails absolutely free. But we are in France, we are in Paris; and a practical spirit is, unfortunately, the only thing we lack."

How much all this sounds like the talk of our own newspapers!

The attacks of the press were so persistent, and the displeasure of the public so marked in various ways, that M. Alphand was summoned before the Municipal Council. In his speech, reported at length in "Le Figaro" of December 12, 1879, he referred in the following words to some of the statements made in the newspapers:

"Foreign countries have been mentioned; it has been stated that in them the snow is removed immediately. Brussels has been given as an example; now I myself was in that city three years ago, at the very time when they had a fall of snow; I declare to you that I did not see a single cart carrying away snow, and when it thawed people splashed along in a black mud twenty-five centimetres thick" (ten inches).

M. Alphand stated that there were at that time employed in removing snow 13,940 men, 3,900 horses, and 2,400 carts.

Imagine our Board of Apportionment supporting the hands of its public officers, in trying times, in this fashion!

This immense body of laborers was put at work before the middle of December. And how much did they accomplish?

On January 5th a correspondent writes: "Beneath our feet such mire as has not been seen since the first week succeeding the original deluge. . . . *From the first fall of snow, upon the 4th of December, the regular scavenger service was suspended, and now, that the snow has melted away, great heaps of offal and filth of all sorts lie rotting in the open air.*" (The italics are mine.)

In a letter to the "New York Evening Post," dated at Paris, January 6th, Edward King writes: "Coming into the city after a brief journey to Spain a day or two since, I almost fancied myself in New York, so familiar seemed the long banks of snow, garnished with dirt and the refuse from kitchens. The municipal authorities have been unable to maintain their reputation for promptness in street-cleaning, in presence of the unaccustomed snowy visitation."

As late as February 18, 1880, more than two months after the snow-fall, and with mild weather intervening, notwithstanding the efforts of 14,000 men and the expenditure of $100,000, "Le Figaro" has the following paragraphs:

"There still remain, in many of the side streets, disagreeable reminders of the snow of last December. Thus, to mention only one instance, but one that counts, we call attention to the streets and passages of the districts bordering on the Eighteenth Ward (arrondissement). The streets and narrow alleys lying between the Rue Ordener and the fortifications, and between the long Rue des Poissonniers and the Avenue de Saint Ouen, are in a wretched state. Heaps of filth, composed of earth-mixed snow, vegetable scraps, and refuse of all kinds, stagnate in the puddles formed by the holes in the pavement.

"The complete repair of this pavement is absolutely necessary. The old women of the quarter quarrel every day about who shall clean in front of the houses, and the streets remain filthy.

"Between the passages Traëger and des Poissonniers there is an open space of about one thousand square feet" (one hundred square metres). "This space is now a mere slough of filth, where the inhabitants, careless of sanitary laws, deposit the most unseemly products of their meals." (Something left to the imagination here.)

"Let there be a hot sun, and an epidemic will sweep away the tenants of these hovels by the hundred.

"Note to the Commission of Hygiene and Public Health, and to the ashmen. The tenants of this quarter have lost the habit of seeing these men."

The extraordinary parallelism between such passages and the comments of our own newspapers in the spring of 1879 will be noticed by every one.

Query? If 14,000 men and $100,000 are unable to clean 2,667 acres of street in Paris in two months after a snow-fall of twenty inches,

what ought in justice to be expected from a force of 400 men, with no extra appropriation, working on 1,415 acres of street in New York, after a snow-fall of eighteen inches?

In London, such snow-storms never occur; but, that the authorities find it difficult there also to keep the streets in that condition of perennial neatness demanded by the press and the public, the following extracts will show:

"There is a natural dowdiness about the streets of London, especially in autumn, which is perhaps incurable. . . . The pavements begin to be deeply smeared with that peculiarly nasty London slime, which can only here be produced in its glutinous and slippery perfection."—("Saturday Review," November 1, 1879, p. 531.)

"The streets of London are being much improved by wood pavement" (they will find this a mistake), "but they are still allowed to remain in a condition of dirt which can not be otherwise than very injurious to the public health. London smells are as objectionable as London noises, and in removing the latter some attempts might with advantage be made at least to diminish the former. This end would in great measure be attained by a proper system of street-cleaning. Under existing arrangements there is no provision for a thorough and periodical cleaning of the roads. They are not even swept, the result being that in dry weather they are littered with refuse and abominations of various sorts, which pollute the atmosphere and fully account for the *unpleasant odors which have during the present summer prevailed in the metropolis and been the cause of general complaint.* Water-carts are of very little service in washing the streets; they may lay the dust for the time, but they merely transform it into mud without removing it. Heavy thunder-showers exercise a more beneficial effect, but their visitations are uncertain, and the manure they wash into the drains often stagnates in the sewer, and might be turned to profitable account if collected and disposed of. The attention of the vestries has lately been called to the whole question of street-cleaning by the National Health Society, and the sooner some steps are taken to purify out-door as well as in-door London the better."—("St. James's Gazette," quoted in "New York Sun," September 5, 1880. The italics are mine).

The bad odors above mentioned are also referred to in the following extract from the "Lancet" of May 29, 1880: "Attention has at length been drawn in the daily press to the disgusting smells pervading many of the principal London streets at the present moment. A correspondent likens the smell in Victoria Street, Westminster, to that of a charnel-house; and the smell in the Quadrant, Regent Street, on Friday and Saturday last, was so like that of carrion, that we heard the question debated whether it did not come from some open windows in the houses near the spot where it was felt" (*sic!*), "and might not arise from some, perhaps unknown, carrion there. But this is not the

only part of Regent Street which has recently been distinguished by a foul smell. The stench (arising from foul sewage according to some, from foulness of the roadway according to others) has been specially obvious to the passer-by about the center of the street, and between Oxford Circus and Margaret Street. In the latter place it was particularly disgusting on Saturday evening. Other streets in the West of London have, and are, suffering from persisting stink" (*sic!* punctuation and all). "It has been suggested that this offensive state of things has arisen from the long spell of dry weather, and consequent insufficient flushing of the sewers or streets, or both. But are the sanitary authorities of the metropolis so wanting in ingenuity, energy, and means that the effects of absence of rain upon the sewers and streets at this time of the year can not be counteracted?"

From the above it appears that New York is not the only city where rain is expected to help in cleaning the streets, or where the public authorities are expected to make up for the meteorological defects of an exceptional season.

In the removal of ashes and garbage, London does not seem to be much in advance of New York, as witness the following extracts: "What can be more unreasonable than the practice of accumulating kitchen stuff and household dirt of every description in heaps under our windows during the heat of summer? . . . The scavenging of our cities and towns is done by contract, and the men employed in the work are so underpaid that, as a matter of experience, they decline to discharge their duty except when bribed by householders. Complaints reach us of the extent to which the practice of levying black-mail is carried by the London dustman, and doubtless the evil is rife elsewhere. Servants are powerless to compel the inert and insolent men who parade the streets with carts to empty the dust-bins. . . . Altogether, the system of clearance is a *fiasco*."—(London "Lancet," August 17, 1878, p. 233.)

Substitute garbage-box for dust-bin in the following letter,* and it might do for the complaint-book of the "Herald":

MEADOWSIDE, PUTNEY, *September* 20, 1880.

SIR: At an inquest held a few days ago on the body of a child who died at Lisson Street, Marylebone, the coroner, Dr. Hardwicke, commented strongly on the serious injury to health occasioned by the present system of allowing dust-bins to remain in London and its environs for lengthened periods without being cleaned out. Perhaps you would bring your influence to bear in this matter, which certainly appears to me to require looking into.

An uncleaned dust-bin, with its festering mass of decaying animal and vegetable refuse, particularly in hot weather and in crowded districts, is a grave evil, as any one who has given the slightest attention to the matter of hygiene will allow, and the present system of having them emptied once in a fortnight is simply absurd. Of course, *those who are addicted to cleanly habits can have their*

* London "Lancet," October 2, 1880, p. 563.

dust-receptacles attended to oftener by entering into a private contract with the dustmen; but those whose means are straitened, or who can not afford this luxury, must be content to endure their pestilence-breeding bins, with all the foul odors and health-depressing influences attached to them, until such times as it may please the dustmen to give them a *dirty clean-out*, the visits of these gentlemen being, like those of the angels, "few and far between," in the poor and crowded districts of this great city.

I have frequently been told by members of the working classes that *it is no unusual thing for the dust-bins in their neighborhood to remain unattended to for months at a time;* and, when they appeal to the dustmen in charge of any passing cart, they are either laughed at or met by a volley of abuse for their pains.

Surely such a state of things, which is easy of remedy, should not any longer be permitted. Yours truly,

G. Stanley Murray, M. D.

The italics in this letter are mine. The writer shows his imperfect acquaintance with the necessities and difficulties of the public service, in the last paragraph, when he writes, "which is easy of remedy." To be sure, the remedy seems plain enough to any one who has never tried to make his own plan work practically. All that is needed is a few carts, horses, and men, with system, energy, intelligence, and industry—men with the latter qualities, as is well known, being exceedingly plentiful in the world, and their services dirt-cheap. A writer in the "Contemporary Review" for October, 1879, page 294, Henry J. Miller by name, representing himself as a poor man appealing to the upper classes for aid in bettering the condition of the poor, makes the following suggestion in his article "Lazarus to Dives," which, as an off-hand solution of a great problem, equals anything in our own daily journals: "Furnish" every householder "with two boxes, varying in size according to the dimensions of his domicile: one to form a receptacle for dust, cinders, old rags, broken bottles, and what is generically known as 'dry dirt'; and the other for decayed vegetables, the entrails of fish, and that kind of refuse that we rather uneuphoniously call 'muck.' Such boxes to be taken away once a week, and empty ones left in their stead. As a corollary to this, forbid him, under penalties, to continue his present practice of pitching derelicts into the street, as the readiest means of being quit of them; and make him responsible for the cleanliness of his door-steps and the pavement in front of his dwelling."

I have but one more subject to touch upon. In the spring of 1878 a determined effort was made by a public-spirited citizen to have the Health Commissioners of this city punished because they did not drive all offensive businesses out of the city. The attack upon them failed, and it failed for the same reason that similar attacks have failed, and will fail elsewhere, and that is, because the trades classed as offensive constitute an important part of the industries of a great city, and their banishment would strike a terrible blow at her commercial prosperity.

The meat business alone in New York runs up toward a hundred millions annually, and the city can not afford to lose it, with the hundreds of smaller allied businesses that must inevitably follow it wherever it goes. I have brought up this subject because, singularly enough, the same trouble and similar complaints have arisen in Paris this summer, and the parallelism between the course of the journals there and here is as marked in this case as in the others mentioned above.

The Paris correspondent of the London "Lancet," in the issue of July 31, 1880, writes: "For some time the atmosphere of Paris has been anything but agreeable. Toward the evening, an unpleasant smell—or rather a more unpleasant smell than usual—has been noticeable, so much so, indeed, that it has at last become offensive even to the republican nostrils of the Municipal Council. This odor has been supposed by some to emanate from the sewers, while others have attributed it to putrefaction in the numerous *kiosques* which adorn (or disfigure?) the boulevards. It would appear, however, that the effluvium originates outside the fortifications, in the twenty-seven *dépotoirs*, or night-soil depots, which at some distance surround the capital, and perhaps also in the sewage-boats which are anchored in the Seine, near the Pont des Invalides. It depends in a great measure upon the absence of the disinfectants which should be used by the contractors who empty the cesspools, but who appear, from the statement of one of the Municipal Councilors, to have been abetted by the police in their neglect."

A month later, August 28th, the same correspondent writes: "The pestilential smells which have infected Paris for some time are awakening a feeling of indignation against the responsible authorities, which is expressed freely in the daily papers, and that quite independent of party spirit. A few days since the well-known critic, Francisque Sarcey, devoted an article to this matter in the 'Dix-Neuvième Siècle,' and invited the inhabitants of his district to sign the petition in preparation against the nuisance; and the 'Figaro' of to-day prefaces some satirical remarks by the statement that 'Paris est en ce moment infecté par les odeurs les plus épouvantables. Tous les égouts sont à découvert.' The odors, which in reality emanate, as was stated in a previous letter, from the night-soil *dépotoirs* which surround the city, and also from the carts and boats which convey the sewage outside the walls, are due to the neglect of the contractors in the use of disinfecting measures, and *there seems to be no doubt about the connivance of the police at this abuse*. . . . The 'Petite République Française' thinks that *the only remedy lies in the suppression of the bureaux which are fallaciously called 'sanitary' or 'hygienic,'* and which cover the responsibility of the prefect by a semblance of official sanction, which, as a matter of fact, they can not withhold." (The italics are mine.)

The usual hasty charges of corruption and incompetence, it will be observed, and the usual expression of a belief that matters could be mended by turning the incumbent officers out of their places and putting green men in their stead!

Meanwhile the Council of Hygiene was busily at work tracing the source of these odors, and endeavoring to find means of suppressing them. The "Journal Officiel" of October 7, 1880, contains the report of a commission appointed for this duty, in which they take strong ground with regard to the harmlessness of the odors, so far as the public health is concerned. It has always been maintained by the Board of Health of this city that the odors complained of by our citizens were not detrimental to health, but only destructive of comfort, and its officers have been much ridiculed for this opinion. It is not unpleasant, therefore, to find that the corresponding board in Paris takes the same view. The following extract will show this:

"The commission deems it necessary, in the first place, to reassure the public with regard to the influence exercised by sewer emanations upon mortality and upon the diffusion of contagious or epidemic diseases. In a communication to the Academy of Medicine, March 6, 1877, M. Bouley has stated that the proof of this contagious action, far from being demonstrated, was contradicted by certain observations. This doctrine has been maintained in the Council of Hygiene, by MM. Bouchardat and Hillairet, whose authority in such matters is well known. The emanations from the mouths of sewers, as well as those from the great chimneys of our factories, do not contribute, in any degree whatever, to the development or propagation of epidemic affections."

In this report, the bad odors complained of in Paris, especially during August and September, penetrating to the center of the city, are attributed to the ventilating shafts of "fosses d'aisance," the dépôts des vidanges at Billancourt, Aubervilliers, and Les Hautes-Bornes, Arcueil. As remedies they recommend the prompt prosecution of persons who discharge night-soil into the sewers (which is not allowed in Paris, and accounts for the cleanliness of her sewers), the thorough flushing of the sewers, a vast increase in the water-supply for cesspools and water-closets, the ventilation of the sewers, and the strict supervision of fat-rendering establishments. And they add that, "in seeking these means of prevention, we do not lose sight of the just recommendation of the Minister of Agriculture and Commerce, dated January 7, 1878, that *they ought to be practicable and susceptible of being put in operation without entailing the suppression of the manufactures themselves.*" (Italics in original.)

The report lays great stress upon the facts that the odors from poudrette-works, fat-rendering establishments, fertilizer-works, etc., are not injurious to health, and that a suppression of these works, such as the public demands, would result in great inconvenience and even

danger to the city: "Il faut le reconnaître, ce sont des établissements nécessaires."

M. Alphand, chief of the Department of Public Works, who was held partly responsible by the public for the state of affairs, made a speech before the Council of Hygiene, October 1st, which is reported in the "Journal Officiel" of October 7, 1880. He speaks more at length than the commission above-mentioned with regard to establishments of the kind that have caused so many complaints in New York. He says:

"The abattoirs of La Villette give rise, as our colleague Dr. Voisin has remarked, to disagreeable odors. These odors do not come, as has been supposed, from the barge which receives the manure and entrails of the slaughtered animals; those matters are, in fact, thoroughly disinfected and removed daily. The bad smells which escape in the vicinity of these abattoirs of La Villette are produced by the fat-rendering, which is done immediately after the killing. This is a nuisance inevitably connected with all establishments of this kind. . . .

"There is, at the gates of Paris, between the Chemin de Fer du Nord and the canal, all along the street La Haie-Coq to Aubervilliers, a collection of factories that treat animal matters and spread abroad nauseous smells. . . . It can not be too strongly insisted upon that these emanations, so objectionable to the sense of smell, have no miasmatic character, and are not dangerous in a medical point of view. . . .

"An evident proof of the harmlessness of these odors, as far as the public health is concerned, is found in the following figures: The complaints of bad odors began in August and increased in intensity up to the month of September. Now, the mortality lists, for the first week of August, show 1,114 deaths; the list for the week from September 9th to 16th shows only 881, a number smaller than the average when Paris is in the best sanitary condition."

The following words of M. Alphand are worthy of consideration here in New York:

"Besides, the public must not demand the impossible, and the production of emanations more or less disagreeable, more or less offensive, can never be completely avoided in the midst of this collection of two million human beings, and many hundreds of thousands of animals—dogs, cats, horses, cattle, poultry, etc."

The speech of M. Alphand was not dealt with tenderly by the newspaper men, who naturally knew much more about the subject than he did. M. Francisque Sarcey, in the "XIXième Siècle," scarifies him in the following terms, which lose much of their vigor and sarcastic force in the translation:

"M. Alphand deduces from this very unanimity an argument against the press; it is the newspapers, he says, that have thrown bitterness into the question. It is they who have made all the trouble!

By crying out against the bad smells, they have finally persuaded the Parisians, and even foreigners, that these bad smells really exist. Before this concerted outcry, Parisians never noticed that it stunk in their city. Now, behold! they are all up in arms against this pretended infection. Who is to blame? Those incorrigible gabblers—the newspaper men. For a trifle, M. Alphand would be willing to say that it is we who are malicious enough to stink, for the pleasure of giving trouble to the authorities. For the past week it stunk every evening in my quarter, and it stunk strongly. One evening, in particular, it stunk so that I found myself compelled to shut my windows, and then it only stunk the more. On my honor! yesterday morning I had an article to write; I am in the habit of entertaining our readers with all the subjects that interest me, and just at the time when they interest me, and, as it stunk in my quarter, I immediately said, with my usual *bonhomie*, 'Oh, my children, how it stinks in my quarter!' No, you can not imagine how it stinks in my quarter. This phrase is my witness that I did not ask myself, before uttering this cry of suffering, whether M. Andrieux had made an arrest the night before, nor even whether M. Andrieux was the prefect of police. I said, it stinks, because it stunk, with the ingenuousness of a man who holds his nose, exclaiming, 'My God! how it stinks!' " *

The war of words between the public and the officials is still going on, and is becoming more virulent. At the session of the Conseil Général of October 26th, M. Raspail is reported to have made "a furious attack on the prefect of police, in reference to the factory at Les Hautes-Bornes, the worst of all the factories surrounding Paris, which had been already closed by M. Léon Renault. In spite of M. Voisin, this factory was reopened, thanks to the influence of M. Léon Say, a friend of M. Pauville, the new owner. The papers drawn against this establishment are flawless. Workmen refuse to labor in summer in its vicinity, and those who do work there are seized with vomiting. In place of closing this pestilential center, it is allowed to grow larger. And this is the history of the other depots and ammonia-factories in the suburbs.

"These bastilles of infection," says M. Raspail, "must disappear, and they will disappear, I assure you, in spite of all possible protection." †

This paper is already too long. I have had in its preparation but one object, viz.: to demonstrate that some of the nuisances existing in New York continue to exist, not on account of the ignorance, incompetence, or negligence of officials whose duty it is to abate them, but because there arise in connection with their suppression certain vast problems which are not yet solved anywhere in cities of equal size with this. And these problems do not lie on the surface, but only con-

* "Lancet," October 16, 1880, p. 639. † "Figaro," October 27, 1880, p. 5.

front the theorist when he applies himself to practical work with personal responsibility, and he begins to find that the means at his disposal are inadequate to the results expected from him.

CEREBRAL LOCALIZATION; OR, THE NEW PHRENOLOGY.*

By HENRY DE VARIGNY.

"WHEN the one who listens does not comprehend, and the one who speaks understands as little, you have metaphysics," says Voltaire. Taking this as a true definition, we may say that there has been, and yet remains, much metaphysics in the treatment of the functions of the brain. But the difficulties in cerebral physiology are great. There is divergence of hypotheses, the facts themselves are not settled, and contradictions abound. The foundations of the science are yet deficient. But it does not follow that experiments are useless. For half a century important researches have been carried on; and more recently facts have been discovered to which we would here draw attention.

From an anatomical point of view the brain is composed of two symmetrical halves, right and left, united by a voluminous commissure, which probably puts into communication the homologous parts of the two hemispheres. Each hemisphere consists of a central mass, with its envelope of convolutions. The central mass, partially separated from its outer covering by the lateral ventricles, is composed of two round bodies, formed of gray nerve-cells—the active part of the nervous system. The office of these rounded ganglia seems to be to strengthen the impressions that come from without, or from stimulated parts of the brain itself, and they may take part in automatic actions. They are in relation, on the one hand, with the spinal cord, and perhaps, more or less directly, with most of the motor and sensitive fibers of the body; on the other hand, they are connected by fibers with the gray matter which is spread out in layers over the convolutions of the brain. In other words, the nerve-cells forming the periphery of the convolutions give out white fibers, which penetrate the central ganglia, probably connecting themselves with their cells. From these cells other fibers proceed toward the cord and extremities of the body. The central masses are on the line of the cerebral fibers between their origin in the gray cells of the convolutions and their termination in the cord and body generally.

* Translated and abridged from the "Revue des Deux Mondes" by Miss E. A. Youmans.

This anatomical arrangement seems to indicate that the peripheral substance, and not the central mass, is the point of motor stimulation and the seat of sensitive impressions. It is everywhere admitted that the brain is the organ of thought and will; but for a long time it was believed that the central mass was the important portion, and the convolutions were disregarded. Hippocrates thought they were only a gland. Malpighi and Vieussens thought the same. Ruysch, from their vascularity, considered them as a simple sanguinous network, and Boerhaave and Haller adopted this conclusion. Vic d'Azyr was the first to examine their structure; then came Baillarger, Ehrenberg, Purkinje, Meynert, Luys, Betz, and Charcot, who revealed their precise anatomy. As to their physiology, Gall taught that intelligence is a function of the convolutions; Desmoulins added that the degree of intelligence is in proportion to their number and depth; and Broca, taking the ideas and facts of Dax and Bouillaud, announced the first discovered localization—that of articulate language in the third left frontal convolution.

In 1870 two German scientists, Fritsch and Hitzig, passed a current of electricity across the head and behind the ears of a living subject, which caused movements of the eyes. They referred these movements to stimulation of the gray matter of the convolutions, and set about the verification of their hypothesis. From their experiments they drew the three following fundamental propositions: 1. There are in the head convolutions that may be excited by electricity, and this excitation is followed by the production of determinate movements depending upon the point excited; other parts being excited without producing movements. 2. The points, which under stimulation induce action in such and such muscular groups, occupy a very limited portion of the cerebral surface. 3. The extirpation of such a point of the surface, known to be a center of distinct movements, paralyzes these movements.

The theory of cerebral localization assumes as proved that there is in the brain a peripheral portion devoted to the production of movements—a motor region; and another where stimulation is not followed by movements—a non-motor region. It further assumes that the motor region may be subdivided into a certain number of small tracts, definitely circumscribed, each of which presides over the movements of a certain muscular group and this group alone. Ferrier, starting with these conclusions, proceeded with the research, and seems to have established—that the convolutions, in man as well as in the lower animals, may be separated into three regions: the anterior, devoted to intellectual functions; the middle portion, charged with the motor innervation of the body; and a sensitive region where are received the impressions made upon the sense-organs by the external world. To show how Ferrier reaches and justifies these conclusions is the object of this article.

Two methods of investigation are open to the physiologist—the experimental and the clinical. In the order of time, the first and the most practicable is the experimental method, which consists in observing the brain through openings in the skull and exciting the convolutions or removing them according to the end proposed. This method is applicable only to animals; and the monkey, from the likeness of his brain to that of man, is best suited to these investigations. But experiments upon other animals are very useful. They show the homologous regions in different cerebral types; and the inequality in relative importance of the central masses, the region of automatic functions, and the convolutions, the region of the will. The great advantage of this method is that the operator can repeat the experiments indefinitely upon all sorts of animals, varying the conditions, and choosing his own time and place. Lesions can also be better circumscribed, and the autopsy can be made at will. On the other hand, animals can not tell their sensations, and we have to judge as best we can as to affections of the intellectual and sensational regions. And the preliminary operations may cause general symptoms that mask the phenomena to be studied. Still, this method is in merited favor, and it will yet yield answers to many questions if we know how to put them.

All the processes of experimenters may be reduced to two categories, according to their effects upon the functional activity of the convolutions. These are irritating lesions and paralyzing lesions. Irritating lesions provoke spasms when applied to the motor region, subjective sensations when applied to the sensitive region, and delirium when they affect the intellectual region. Paralyzing lesions in the motor region paralyze the normal action, and in the sensitive and intellectual regions bring on anæsthesia and mental depression. But this division applies only to immediate results, for it is not rare to see a lesion, whether experimental or in clinic, provoke symptoms of irritation in the beginning, followed by paralytic symptoms, and reciprocally.

Experiments that produce prompt paralyzing effects are more numerous than those which excite the functions of the convolutions. But the most preferable one, and that adopted by Ferrier, is the method of limited ablation. By it lesions can be more circumscribed, it affords a sure means of control, and hence it has come largely into use. Electricity is the only process for exciting the functions to greater activity; and since it has been much opposed, and is the sole support of the theory of cerebral localization, we must defend its legitimacy.

It may be remarked that the convolutions of the brain are in the form of long, round, gray swellings, separated by furrows. Each of these swellings has a direction, relations, and a situation peculiar to itself, and identical for all animals of the same species; and the princi-

pal ones have their homologues in all animals. They have also their special names. When the excitant is moved about over the different convolutions, the existence of the motor zone is made manifest by the successive movements of the animal; the sensitive zone is known by signs of sensation, while the indications of an intellectual zone are not thus positive. Observe what passes when we irritate the so-called motor region. We excite a certain point of the convolutions, and a movement is produced. Groping about with our electrodes, we find the effect limited to a small tract where at all the points the same movement is provoked, and that alone. Next to this zone, we can in the same way find the limits of others presiding over other movements. The influence appears greatest at the center of the zone: exciting the periphery sometimes produces a light supplementary movement belonging to a neighboring zone. The special centers or zones being very near together, our means of electrizing them are not perfect enough to prevent a slight diffusion of the current into neighboring centers and faintly exciting them. To get precise separate effects we must excite the center of the special zone.

As the same movement invariably follows the stimulation of a special center (the name of a special zone), we conclude that the center in question has charge of this movement, and, as a great number of these centers, placed side by side, preside over most of the movements of the body, we infer the existence of a motor region of the brain, the seat of voluntary control of the body. But, since, as the galvanometer shows, the electricity is diffused over neighboring centers, what right have we, it may be asked, to assert that the movement observed, when a certain center is excited, is due to that excitation, when neighboring centers are also excited? We reply that to these facts we can oppose other facts. On removing the electrical conductors scarcely a centimetre, we excite perfectly definite unlike movements, although the current is diffused as before. Why are not the movements last produced the same as those observed at the first position? Why such distinct localization in spite of diffusion? Although the occurrence of diffusion is proved by means of sensitive apparatus, it is physiologically insufficient. Besides, it can be prevented by proper precautions.

Again, it is asked if there may not be such a thing as diffusion beneath the surface? This is a grave question, for, under the motor region, there is a large ganglion containing motor fibers going to the muscles. If the current diffuses downward as far as this ganglion, we can not assume that the convolution alone is excited. There are three answers to this objection: 1. The excitation of the convolutions nearest to this ganglion gives the least results; sometimes no movement at all. Unless we admit that the effects are directly as the resistance, which is absurd, downward conduction can not be affirmed. 2. Braun has demonstrated that a section of the white fibers below the excited points, interrupting the physiological continuity, does not

arrest electrical conduction sufficiently to prevent movements. 3. Ferrier has shown that the direct excitation of this ganglion produces a general muscular contraction of the other side of the body, and not special isolated movements. So that we again conclude that, though electrical diffusion toward the corpus striatum (the name of the ganglion in question) may exist, it is physiologically insufficient.

But, it may still be asked if electrical diffusion does not excite the white fibers interposed between these convolutions and the ganglion beneath. This objection borrows a character of probability from the slight thickness of the layer of gray matter of the convolutions, and also from the alleged unexcitability of the gray substance, which has been proved in the case of the spinal cord, but conclusive proof in regard to the brain is yet wanting. Many physiologists claim that these cells are only excitable by the will. For the theory of motor-centers they substitute that of psycho-motors. Reserving this discussion for another time and place, we may say that, whether we excite the cells or the fibers that arise from them, the result is the same.

All stimulation, whatever its nature or origin, acts upon a nerve according to its functions. Excite a motor nerve at any point of its course, and you produce movement ; excite a sensory nerve, and the subject will feel a sensation which will vary with the nature of the nerve. Compress the eyeball, you excite the optic nerve and get the sensation of light ; auditive nerves give sensations of sound, and so for all the nerves of special or general sensibility. If, then, in the brain we excite the motor region, the origin of the motor nerves is irritated, and we get movements ; excite the sensitive region, and in place of movement we have sensation owing to the connection of these nerves with sensitive cells. So that the electrization of the gray matter of the convolutions acts in the same way as the electrization of a nerve on any point of its track ; the only difference is that in one case we excite them at a point near their origin. From the anatomical relations that exist between the white fibers and gray cells, we infer that the cells play the rôle of center to the nerves.

We come now to the details of Ferrier's experiments. Ferrier operated chiefly on monkeys, because in them the will is in the ascendant, while in lower animals automatism preponderates. As the result of his experiments, he affirms the existence of three zones—the intellectual, motor, and sensitive—into which the surface of the brain can be divided. The one best known, and to which least objection has been made, is the motor zone. In passing the electrodes over its surface, we soon find the little, well-defined centers that preside over particular groups of muscles. Under the microscope there is seen at these points a limited mass of large cells, called *nests* by Betz. The functions of these centers are best shown when they are electrized at the central point, the current being then less likely to spread, and so produce more complicated movements that mask the true function of

the center under experiment. Here electricity provokes movements of the leg on the opposite side, owing to the cross-action of the hemispheres. It moves as if to go forward; or the movement may be limited to the foot, or even the great-toe. Sometimes the motions are still more complex, and involve many muscles, as if the animal would scratch its breast or press against it some object which it had taken from the ground. Again, it is the arm, forearm, or hand that moves in various ways, and to different ends; sometimes there is a combination of movements, like those required for swimming or prehension; the fingers may lock together with force, as if to retain an object, or extend themselves with a lively movement, as if to scatter something. It is probable that, if our instruments were more perfect, we should find in each center a number of subordinate centers for the execution of single movements, or the moving of a single muscle.

The general idea of the relations of the brain and spinal cord is that the brain commands and the cord obeys. The brain requires such or such a movement, and the cord, working unconsciously, coördinates the elementary and individual movements required to produce the desired effect. Electrizing the centers is the same as issuing an order to the cord, not of directly exciting movement.

Monkeys being difficult to obtain in our climate, to satisfy the constant needs of experiment, Ferrier operated upon dogs, jackals, Indian pigs, rats, pigeons, frogs, fishes, anything that was going. These experiments fully confirmed the results otherwise obtained, and showed, besides, that the action of the hemispheres is of less importance as we descend in the animal scale, while automatism rises.

Ablation of a limited portion of gray matter of the brain leads to the same conclusions as electrization. It produces paralysis, and monkeys rarely or imperfectly recover from these lesions, while inferior animals, as the rabbit and Indian pig, recover; thus showing that the voluntary centers are more important in monkeys than in lower animals.

Such are the facts on which we base the existence of a motor region in the brain. Putting aside all questions of interpretation, it is undeniable that there is a region in the brain where stimulation produces movements varying with the zone or center excited.

Behind this region we find the sensitive centers which receive impressions made upon the sensory nerves, and form perceptions from them. As the terminations of the nerves of sensation are specialized, in exciting the centers we produce subjective sensations, like those caused by cerebral maladies, in which the intellect refers to the outward world the origin of sensations, of which the cause is in the brain; and, whether voluntarily or by reflex action, the animal operated on by electricity shows by evident signs the nature of the sensations he experiences. By means of counter-verification we determine the exist-

ence and topography of a certain number of centers which Ferrier has studied with great care.

Take, for example, the visual center: its stimulation caused disordered reflex actions, indicating unpleasant visual perceptions. This alone is insufficient proof; but we can control the region in question by ablation, which brings on unilateral or bilateral blindness, according as we operate on one or both of the visual centers. Stimulation of the auditive centers, in the same part of the brain, provokes movements of the ears, eyes, and head, showing astonishment or terror, just like those caused by a violent and unexpected noise. Ablation causes deafness; the animal remains indifferent to all sounds. Excite the centers of touch, and the signs indicate disagreeable or painful tactile impressions. Ablation brings on complete anæsthesia of the same parts; you may prick, cut, and bruise the animal, and he remains insensible.

Some experiments seemed to indicate the existence of centers of taste and odor, but it is difficult to trace their limits. They are intermingled like the gustative and olfactive sensations. Electricity causes movements indicating unpleasant tastes and odors, and extirpation of the parts ends these sensations. The animal will respire odors, or taste savors that in the normal state would make him fly about the laboratory, and it all passes unperceived. Still more hypothetical are the centers of the organic needs of hunger and thirst, and more yet those of sex, but Ferrier's arguments are strong in favor of their existence.

The presence of a third, or intellectual region, is proved, as far as it can be, by experiments on the lower animals. It is difficult to understand the mental action of a dog, Indian pig, or even of a monkey. Ferrier observed numerous facts tending to establish the intellectual function of the anterior region of the brain. Electricity could hardly be employed in these researches; but ablations, when performed with caution, brought on notable changes in the habits of animals. The monkeys chosen by Ferrier were remarkable for their vivacity and intelligence, prying about right and left, and observing everything. After the operation they became stupid and apathetic. But these indications are not convincing. The clinic alone can decide whether physiology sustains the doctrine of cerebral localization.

We know in what the clinical method consists. Applied most often to man, it amounts to this: to observe the symptoms of cerebral disease, and at the autopsy to connect the lesions, discovered by the naked eye or the microscope, with the symptoms, as cause and effect. It is true that in cerebral pathology there is great difficulty in separating the essential from the accidental, and distinguishing cause and effect among a plurality of causes. Besides, it frequently happens in cases of cerebral disease that at the autopsy no appreciable lesions can be found. The question is still further complicated by the solidarity

that binds together the different parts of the cerebro-spinal system and which makes it probable that a simple local trouble will produce general functional perturbation. The brain is like a complex machine, in which, if a screw loosens, or a nut gives way, or a rod bends or breaks, at once all goes wrong. It is not that the screw, nut, or rod in question is the immediate cause of the movements of the machine, but that the failure of these accessories may, for the moment, produce accidents as grave as would be caused by disturbance in much more important parts. Again, cerebral lesions tend to spread and become general. And yet, we have to accept the lesions caused by disease, for we can not produce them at will.

With these reservations, the clinical method is still of the first importance. By means of it we verify in man the hypotheses of experiment, and assure ourselves of the existence of the intellectual and sensitive regions of the brain. Neither medicine nor physiology opposes the use of the clinical method in cerebral localization. But only circumscribed lesions that have little or no tendency to become general, or to act at a distance by compressing the brain, or otherwise, can come to the aid of our theory. When there is a lesion of the cortical region of the brain which fulfills these conditions, the resulting symptoms may be of two orders—either stimulative or paralytic of the true function. These are the two opposed symptoms that we produce experimentally by electrization and ablation of the substance of the convolutions. It goes without saying that the symptoms vary with the locality of the lesion : the intellectual region gives delirium ; the motor region, spasms ; the sensitive region, subjective sensations. The symptoms of functional paralysis are also diversely represented by mental feebleness, motor paralysis, and anæsthesia limited to one sense. A lesion frequently presents both orders of symptoms, which succeed each other, or alternate, according to its nature. This fact is as important as the division of the symptoms into two great classes. We will now consider the facts in the same order as before.

The middle region of the superior face of the brain appears to be the motor region. In fact, limited lesions of this region bring on marked troubles in the motor innervation of the body, such as monoplegia, or limited paralysis, or equally limited spasms. Putting aside those cases where the lesions cause general trouble, and regarding those where the symptoms are limited, we come at a constant relation between certain lesions and certain troubles. In ocular monoplegia, the eye can not be controlled by the will. Brachial and crural monoplegia are more frequent ; sometimes a single member, arm or leg, sometimes both ; but successively, because of the extension of the lesion to both centers, which are near together. In this case the lesion advances slowly and invasively ; at the autopsy we can often appreciate the differences of age of the extreme points of the diseased spot. Not far from the brachial and crural centers is the center that

presides over the muscles of the face. As before, this center may be affected alone or simultaneously with the other. It depends upon the nature of the lesion whether the invasion is sudden, or slow and progressive, ending in feebleness rather than in paralysis. The proximity of the brachial and facial centers explains their apparent solidarity in the normal state, as shown by the grimaces that often accompany vigorous use of the arms. It seems as if the second center were stimulated by the activity of the first. We close our enumeration of the centers which the clinic has proved to exist by reference to the center of articulate language, discovered long ago by Broca, which attends to the coördination of phonetic movements.

We have seen that lesions of the motor region of the brain may be manifested by spasms as well as by paralysis. These monospasms have been long known, but it was Hughlings Jackson who first attributed them to lesions of the motor region of the brain. Prior to this they had been described by Bravais, but he did not seek for their origin or signification. They are localized convulsions, or partial epilepsy, and Hughlings Jackson thinks they are due to nervous tension. Any new excitement added to those already stored up will produce discharge or spasm. Like monoplegia, they may be limited to an arm or leg, or even the face ; but these phenomena are seldom noticed, and we have few observations upon them. When the spasm involves several parts of the body, it always begins at the same point and follows the same order. Dr. Maragliano has made a very interesting study of partial epilepsy, and explained its causes and signification. Both monospasms and monoplegia indicate the same localization of power.

The sensitive region is found, by experiment, behind the motor centers. While limited lesions of this region often manifest themselves externally as circumscribed anæsthesia, it sometimes happens that they remain latent when they are seated on only one hemisphere. There is no sign of pathological perturbation, and in this case we seem forced to admit functional substitution, or the possibility of the regular action of two sensitive, homologous regions, notwithstanding the absence of one of the two corresponding cerebral hemispheres. What does this signify ? Must we abandon the doctrine of localization as regards the sensitive centers ? A single center suffice for the two parts of the body ? This anomaly is probably due to insufficient observation. Disease of the cerebral centers may give no further symptom than enfeebled sensibility, which might pass unperceived. Lesions of the motor region often result not in total paralysis but in slight paralysis—a feebleness and not an abolition of the functions. But there are cases where lesions of the sensitive region are accompanied by less equivocal symptoms, and it is from these that we affirm localization.

Symptoms may be of two orders, according to the nature and the phase of the disease : symptoms of excitation, which produce subjec-

tive sensations responding to nothing external, and symptoms of anæsthesia manifested by an abolition of the perceptions belonging to the affected part. These two classes of symptoms may also alternate in the same disease, as in the motor and intellectual regions.

A characteristic case, confirming this theory, is that of a child who fell on his head and buried a portion of the parietal in the surface of the brain. He became blind in the eye of the opposite side. He was trepanned, and the blindness ceased immediately. Soon inflammation arose at the wounded part; blindness returned and lasted till the inflammation disappeared. Compression of the visual center, first by the bone and then by the products of inflammation, was the evident cause of this intermittent blindness. Other cases establish the possibility of abnormal stimulation of the visual center.

The centers of hearing, taste, odor, and touch are localized in the same way, and, if the observations are not very numerous, they make a strong presumption in favor of the localization actually adopted. It sometimes happens that several centers are affected at the same time. In these cases, if the lesion is an irritating one, there occurs from time to time a simultaneous discharge producing a singular mixture of sensations. One such patient, observed by Ferrier, said that he had the sensation of a horrible odor and green thunder. We admit that the clinical arguments in favor of the localization of the sensitive centers are not so numerous or conclusive as could be wished. But only lately have they been sought, and each day brings its contribution, which, considering the rarity of limited lesions of the brain, can not be very considerable.

The localization of intelligence in the frontal region of the brain was thought of long before our day. Gratiolet used the expression *frontal races* for intelligent races; and those of least intelligence have been called *occipital races.* The frontal region is greatest in man along with the predominance of reason and logic, while in women, who are dominated by their sensibilities, the occipital region prevails. We may cite to the same point the researches of Bordier on the skulls of assassins, of Luys on the brains of fools and idiots, of Bénédikt on the brains of criminals, of Lombroso on the characters of habitual criminals. Their conclusions are analogous, and favor more than they oppose the popular idea.

But these arguments are not precise and positive. Happily there are others more scientific and more conclusive. Take the celebrated crowbar case, where a young man, who was blasting, had a pointed bar of iron about three quarters of an inch in diameter and weighing three pounds, driven, by a sudden explosion, upward through his head. It entered at the angle of the under jaw, passed behind the nose and eyes, penetrated the skull, and cutting the cerebral substance of the frontal region passed out at the top of the head, above the forehead and to the right of the median line. The wound was frightful. All one part

of the brain was disorganized, without counting the multiple fractures of the skull and face. He was alone, but, in less than an hour after the accident, without help, he walked to the surgeon's, went up the steps, and related the circumstance clearly and intelligibly. He recovered, but died of epilepsy some twelve years later. His physicians and friends observed that his character and intelligence changed notably after the accident. From being intelligent and active he became capricious and unsteady, and had to retire from his post of overseer. Analogous cases to the same purpose might be cited, but we have no space. We need new facts, but those we possess strongly favor the theory of Fritsch, Hitzig, and Ferrier.

We have passed in review the experimental and clinical arguments in support of this theory; and there are others of not less importance drawn from pathological phenomena. But we have no space for their consideration.

M. Brown-Séquard has shown the greatest hostility to this theory. His chief argument is that lesions and symptoms are not coextensive. An insignificant lesion causes general trouble; a considerable lesion remains latent in the matter of symptoms. This is true, but it is the exception; whereas he ought to show that it most frequently happens. The real question is, Does the seat of a lesion signify nothing, and may we have identical symptoms with two very different lesions? And we have demonstrated that this can not occur. The facts cited in opposition to the theory of Ferrier may be embarrassing, and at present inexplicable; but such facts would be far more abundant if we admitted the theory of M. Brown-Séquard.

Again, there is the theory of Vulpian, who thinks that the stimulation of the gray cells by electricity is not possible. For motor centers he substitutes psycho-motor centers. In his view, stimulation of the convolution acts, not on the cells, but on the white fibers which proceed from them. But his mode of interpretation does not alter results, nor set aside the centers.

Goltz made a curious experiment, showing clearly the office of the centers. He took two dogs of the same species, one having the education common to all dogs, and the other some supplementary accomplishments, and among them that of giving the paw. In both dogs he removed the center which presides over the movements of the fore-paw of one side—the one given by the knowing dog. They soon recovered, and could run about. Running is a reflex act, that does not require the intervention of the centers. But, while the learned dog could use his legs, and go and come, he could not give his paw. This was a superior, voluntary act, which could not be performed in the absence of the corresponding center. It is in this differentiation of the organs of voluntary activity from those of automatic activity that we find the explanation of so many singular facts which at first sight seem to contradict the theory of localization.

It is undeniable that there is yet much to be done in this domain. But the results obtained by Ferrier are so encouraging that we hope this new way of studying cerebral physiology will be followed and explored with more care than ever.

A PIECE OF COAL.

By R. S. CALVIN.

A LUMP of coal—black and grimy, and repulsive to sight and touch as it is—is, perhaps, not the most promising subject that could be selected for Sabbath-evening reflections. But, if there are sermons in stones, why not in coal? The black thing, that we would rather not handle when we have any proper regard for cleanliness, becomes an object of interest when we find it exerting energy in the engine-furnace or shedding warmth and radiance around our household hearth. It becomes an object of yet greater interest when we come to learn its wonderful history; for every common bit of coal that we are accustomed to see has a history with which is wrapped up the story of one of the most interesting and critical periods in all geological time. It is the lessons and promises of this far-off history of the coal that constitute the theme for to-night.

Fifty years ago an attempt to tell the history of the coal would, no doubt, have seemed, to all but a very few, not only hopeless, but absurd. Since then the methods of questioning Nature and making her tell her own history have been so much improved, and have been, withal, so energetically applied, that very much, which our grandfathers would have set down as past finding out, has become the mental property of every well-instructed schoolboy.

There are many different kinds of coal, and coal belongs to many different epochs in the world's history, but that which we find in the coal-fields of Iowa and Illinois may be taken as the type of what is usually understood, the world over, when coal is mentioned. Let us fix our attention on a piece of such coal. To extort from that expressionless thing any facts bearing on its history would seem discouraging enough. We may look at it just as long as we please; we may break it to pieces with the hammer and examine it bit by bit, and it is altogether likely that we will be left just as wise and just as hopeless as when we began. Pass it over to the chemist, and he will tell us that it is made up of combustible matter of which so much is fixed and so much volatile, with a certain percentage of earthy substances and traces, perhaps, of ever so many elements that we never heard of before. The information is interesting—in many respects it is of the highest importance—but for the purposes of the present discussion it amounts,

after all, to telling what men have more or less clearly perceived for the last thousand years or more, that *coal will burn*. By proper manipulation we may obtain thin slices of coal suitable for microscopic examination, and in this way may demonstrate that a large proportion of it is composed of what seems to be crushed and flattened vegetable cells. You are all aware that plants of every kind are made up of little microscopic units called cells, and that these cells differ so much in markings and other characteristics in the different groups of plants that one group may often be distinguished from another by the study of the smallest microscopic fragments. Now, in the coal itself, and often in the ashes that remain after combustion, it is possible to

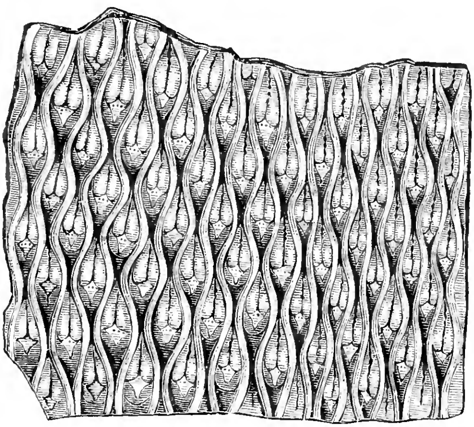

Fig. 1.—Lepidodendron modulatum.

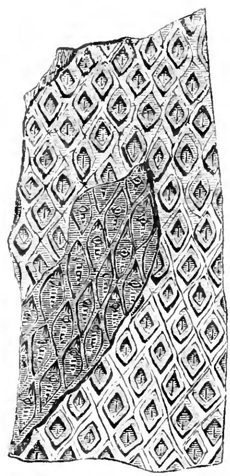

Fig. 2.—Lepidodendron diplotigioides.

recognize the peculiar cells that characterize certain great divisions of the vegetable kingdom; and, as this method of study is extended, we are gradually led to the conclusion that coal has somehow been derived from plants. Let me say, however, that to reach a conclusion and to entertain an opinion on a question of this or any other kind, where matters of fact are involved, is too serious a thing to be accomplished lightly. The color, hardness, and other physical properties of coal, together with the fact that coal-beds are often buried under hundreds of feet of rock and soil, may well make us hesitate before accepting any such conclusion. Let us attempt the solution of the question in another way: All around the globe, in the middle and higher latitudes, are beds of peat. Now, peat, especially when well pressed and dried, presents many very suggestive resemblances to coal. But there is not the slightest difficulty in determining how peat is formed, for we may see the process going on before our eyes. We can study every stage in the process, from the living and dead plants growing and accumulating in the marsh at one end of the series, to the completed peat-

bed awaiting only the proper manipulation to be converted into useful fuel at the other. That peat is formed of plants, and largely of plants that accumulate just where they grow, can be no longer questioned.

In the swamps and bayous of the moist regions of the South, pure vegetable matter, having the appearance and properties of peat, may often be found in the very act of accumulation. It frequently occurs in immense beds, and it requires no trained observation to see that, in addition to the remains of the ordinary low marsh-plants, it is made up of the ruins and refuse of swamp-loving forest-trees. Now, all about the flanks and spurs of the Rocky Mountains, with greater or less intervals, from New Mexico to far beyond the northern limits of the United States, there are found beds of coal of peculiar quality. This coal is covered up with hardened mud containing shells and bones of aquatic animals, and everything about it suggests that the coal-making material was somehow sunk beneath the waters of an old lake, and was buried under the gradually increasing bed of mud with which the old lake-basin was finally filled. But the point of interest is this: that in many places the Rocky Mountain coal has reached a stage of decomposition not so very much in advance of the humus and peat of our modern swamps and bayous. We might, indeed, hesitate about calling some portions of it coal at all—for the original structure is almost perfectly preserved—yet it must be admitted that for the most part the decomposition has advanced far enough to produce an article that deservedly ranks as coal. In the light of what may be observed going on in every favorably situated swamp to-day, the source of the material and the method of accumulation of the Rocky Mountain coal can hardly be doubtful. I need not weary you by leading you step by step through all the known coal-fields that illustrate the different stages in the process of coal-formation. It will be sufficient to say that a perfect gradation may be traced from the lignite, as it is called, of the Rocky Mountains to the purer and more perfect coal of the Mississippi Valley; and so, even setting aside the internal evidence of our Iowa coal, we are compelled to believe that it is simply one of the terms of the same series to which the lignite and the peat belong, and that the initial term of that series is to be looked for in the living vegetation of modern marsh and forest.

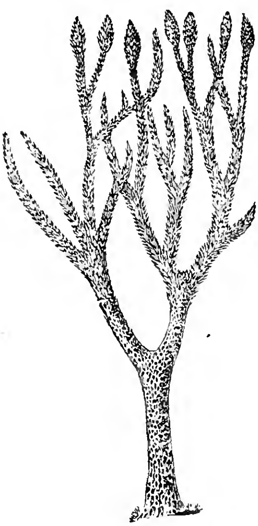

Fig. 3.—Restoration of a Lepidodendron.

The conclusion is interesting, though to an intelligent audience it could hardly be called unexpected. The method of reaching it is worthy of notice, and points some important lessons. Though the

coal of Iowa was accumulated in what is called the Carboniferous age—an age of the world that is immensely distant from the present, infinitely so, indeed, as we count time—yet the processes of Nature were the same then as now. That old world was, in every essential particular, the same world that we know, and was governed by precisely the same laws that control it to-day. What is true of coal is also true of every part of the geological record to this extent: that all the strangely fascinating history recorded in the rocks must be read in the light of what may be seen actually taking place now. It has become a maxim of geology that, if we would know how anything was done in the past, we must study the method in which Nature is doing that very same thing in the present. Following these suggestions a little further, we are led from the study of this particular side of the history of coal, through similar studies, to the grander and more significant

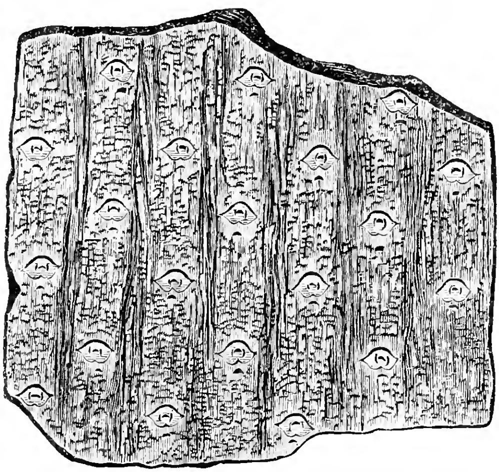

FIG. 4.—SIGILLARIA RETICULATA.

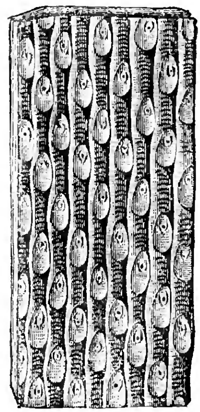

FIG. 5.—SIGILLARIA GRÆSERI.

generalization that the laws that govern the world have been the same for all time; that the laws of matter were imposed upon it as long ago as that old, old nebula of which you have heard, and that there has been no occasion to repeal the old or enact any new laws since.

But we must get back to our coal, and pursue the series to which it belongs a little further. The product of our Iowa mines is one of the terms, as we have seen, in that interesting series, but it is not the final term. We may start with bituminous coals, like those of Iowa, at Pittsburg, for example, and working our way across the State of Pennsylvania toward the foot-hills of the Alleghanies, we will cross one of the grandest coal-fields in the world, and at every stage of progress will pass from more to less bituminous coal, until by almost imperceptible gradations we will find ourselves in the region of anthracite. Anthracite, then, is only another term in the coal series; it

represents only a more advanced state of carbonization than bituminous coal; the difference seems, in some way, to have been brought about by the play of the gigantic forces that gave rise to the mountains, for in all the region disturbed by those forces—in all the region in which the rocks have been folded and crumpled and changed—the coal is anthracite, and anthracite rarely occurs in other situations.

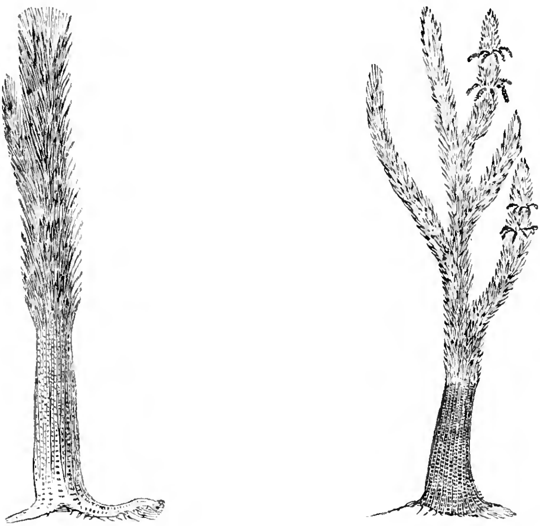

FIG. 6.—RESTORATION OF SIGILLARIA.

Passing over the Alleghanies, we find the disturbing forces have acted with even greater energy on their eastern side, and accordingly in many places the only thing that bears any resemblance to coal is a black substance more perfectly carbonized than anthracite. It is to this substance that we are indebted for the universal use of the lead-pencil, for it is nothing less than black-lead or graphite. And here in a measure we lose track of our series; we find no gradations by which to trace it further, and yet it is as certain as anything can be that graphite is not the ultimate term, for in it we have not yet reached the perfection of carbonization. That perfection is finally reached, however, in the gem of gems, the diamond, the only example of absolutely pure, crystallized carbon. Though the steps between graphite and diamond are not known, we feel sure that those steps, or something corresponding to them, have been taken some time, and that diamond, graphite, coal, peat, and growing forest, all belong to the same series, and represent different conditions of the same thing. And so our piece of coal acquires interest and dignity, and becomes, altogether, a thing not to be lightly despised, for, in addition to its own real worth, it enjoys the advantage of being able to claim kindred with the aristocratic Koh-i-noors of Golconda.

But how are the great ledges of rock above the coal to be explained? Let us see. The rocks in question are very often sandstone, and if we examine them carefully we find that they are spread out in layers, that they contain the remains of many marine animals, and that the surface of a very large number of the layers shows signs of having been washed by waves. With the exception that they are somewhat harder and the organic remains belong to more old-fashioned types, these rocks are exact duplicates of the widely spread layers of sand that the ocean is piling along all our shores to-day, and contain the clearest evidence that they have been swept into place by the waves of some old sea. But how came the coal beneath the sea? That is an important question, and the full answer to it would show that no truth is more plainly taught by all the records of the past and present than that the earth's surface is a very uncertain and unstable affair. You will find your answer to the question on the shores of Greenland, where the coast, for hundreds of miles, is slowly sinking into the sea; the result in historical times being sufficient to convert old marshes into shallow bays over which sands are swept by each returning tide. You will find your answer along the coast of New Jersey, in the buried forests with their prostrate trees and upright stumps, all carried down in very recent times by the subsiding land just within reach of the sea. You will find your answer in the buried forests of the delta of the Mississippi. You will find the same answer in a hundred other places. Large areas of land in different parts of the world are gradually subsiding, and large areas in the Carboniferous age sank down in the same way. Each coal-seam is the record of peat-bog and forest; the overlying rocks record a period of submergence.

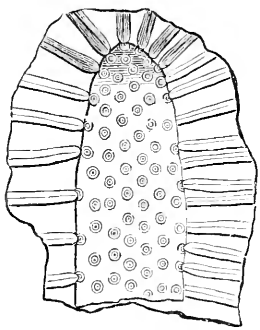

Fig. 7.—Stigmaria ficoides.

But the movements in the earth's surface at present are not all downward; there are, perhaps, as many cases in which the land is rising. During the Carboniferous age, the same thing was true, and it often happened that the area that was carried beneath the sea was, in time, reëlevated, and became the platform on which other forests and peat-bogs renewed the work of coal-making. Thus it is that in many coal-fields we find a number of seams, one above the other, and thus it is that we have registered in the coal-beds of Nova Scotia not less than seventy-six distinct upward and downward movements of the surface. The sinking of the old marsh beneath the sea might seem to involve the loss of all the materials that had been accumulating during periods, perhaps, for which years would furnish no adequate unit of measure, and yet this very movement was essential to the preservation of the great magazines of energy on which human progress so much depends.

I have already referred to it as a matter of considerable interest, that a large proportion of some coal is made up of crushed vegetable cells; but that is not all—a still more wonderful fact remains to be noticed: The microscope, prying into all the little corners and secret places of Nature, declares that the pitchy parts of most bituminous coal are composed almost entirely of little spherical bodies, microscopic in size—so minute, indeed, that hundreds of them together might well be disregarded as "the small dust of the balance"—and yet so numerous that great coal-seams often appear to be made up of little else. Large numbers of them are often found huddled together in small round sacs

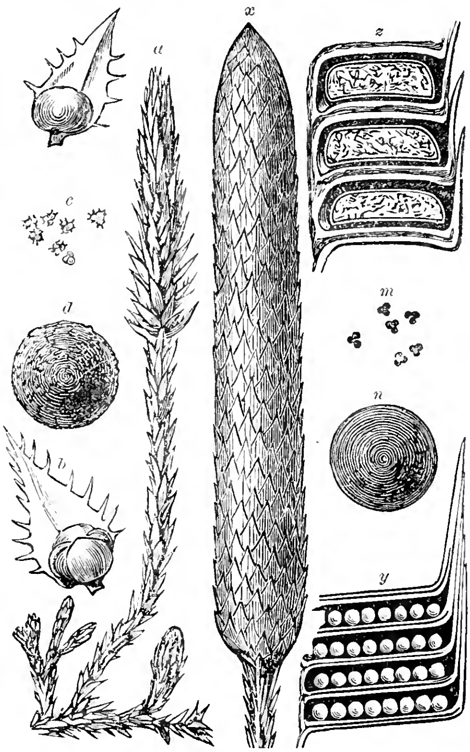

Fig. 8.—Lepidodendron compared with Club-Moss: *a*, club-moss; *b*, a scale enlarged; *c*, microspores; *d*, macrospores; *x*, lepidostrobus; *y* and *z*, the scales containing spores; *m*, microspores; *n*, macrospores.

of peculiar appearance. We are indebted to the patient labor of a number of observers for the fact that the smaller granules are the spores or seeds of some plant of inferior organization, and the larger sacs are fruit-cases in which the spores were developed. The whole history of this fruit, the manner in which it was produced, its relation to the stem and leaves of the plant to which it belongs, even its fertilization and development, have all been carefully worked out with an

amount of labor that can hardly be appreciated, but with results as certain as if the actual development had been watched in the living plant.

The plants, themselves, on which this old coal-producing fruit was borne, and whose carbonized stems and leaves lie heaped up and mingled with the spores, have some lessons of interest for the student of world-history. One of the best known of these plants has been called Lepidodendron, or scale-tree, on account of the beautiful scale-like markings impressed upon the bark (Figs. 1 and 2). These markings—diamond-shaped and arranged in close-set spiral lines around the stem—are scars left by the falling leaves. Elaborately sculptured stems are found in all our coal-measures, often with dimensions indicating trees three to five feet in diameter, and seventy to a hundred feet in height. Such trees, judging from their abundance and world-wide distribution, must have been conspicuous objects in all the forest-covered swamps of the coal age. Conceive, if you can, of tall, rigid trunks, ornamented with delightful patterns of inimitable sculpture-work, rising to a height of thirty or forty feet and these dividing into two equal clumsy branches; then let each of these divide again and redivide until a number—though not a very great number—of smaller branches are produced; then clothe each of the branches with a bristling array of thick-set, lance-like leaves; let each branch terminate in a club-shaped cone or fruit from which multitudes of resinous spores, at the proper seasons, came showering down, filling the air with clouds of dust for days and weeks together, and sifting in among the roots of all the dense undergrowth with which the coal-marsh is covered—and, having drawn this mental picture fairly, you will have some idea, perhaps, of a Lepidodendron (Fig. 3).

But, if we would award credit where credit is due, we must in all fairness acknowledge the preëminent importance of another group of

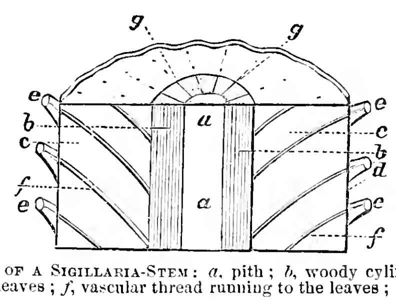

FIG. 9.—IDEAL SECTION OF A SIGILLARIA-STEM: *a*, pith; *b*, woody cylinder; *c*, inner bark; *d*, rind; *e*, bases of leaves; *f*, vascular thread running to the leaves; *g*, medullary rays.

plants to which we are indebted for by far the largest share of the coal. These plants outnumbered the Lepidodendrons in all the swamps; like Lepidodendrons, they rose to the dignity of great trees; the trunks were composed of firmer and more densely packed woody tissue; the bark was thick and rich in bituminous matter, and in some of them it

seems probable that large nut-like fruits were produced in place of spores. They are known as Sigillarias, and differ from Lepidodendrons, in addition to the characters already enumerated, in having stems less frequently branched; the stems are also longitudinally fluted like some great columns of architectural beauty and finish, and between each pair of vertical ribs are now found the leaf-scars in variable but always orderly arrangement (Figs. 4, 5, 6). Instead of at the ends of the branches, the fruit was borne in cones, resembling pine-cones, springing from the sides of the stem. The leaf-scars often resemble impressions made upon wax by the old-fashioned seal, and hence the name Sigillaria, or seal-tree. Great, somber, stiff, post-like things they must have been, as, crowding each other in all the swamps, they lifted to the sky their great, bald trunks, with scarcely any branches, and nothing worthy of the name of foliage. Perhaps we should say that the most important part of Sigillaria was really underground, for all the old coal-swamps seem to have been traversed in every direction with a perfect network of creeping subterranean or subaqueous stems, and from these arose the aërial fruiting stems that we have called Sigillaria. Such underground stems, creeping and interlacing through the peat-like humus, must have formed a much-needed foundation on which to support the tangled forest of vegetation that grew and accumulated in all the quaking, boggy marshes. These creeping stems are called Stigmaria, and were known for a long time as one of the most abundant fossils of the coal, before their relation to Sigillaria was so much as suspected. They have markings arranged something as in Lepidodendron, but when we find them undisturbed—still imbedded by the old soil in which they grew—there arise from the center of the several scars long, thread-like filaments now known as rootlets (Fig. 7).

Almost every seam of coal has been shown to rest on a bed of clay, called among miners the under-clay or dirt-bed. This clay is penetrated in every direction by fossil roots with upright stumps sometimes attached, and it requires no argument to show that it is an old fossil forest bed—the original soil in which some, at least, of the coal-plants rooted and grew. This old soil has always been known to be particularly rich in Stigmariæ with the thread-like rootlets still in place, but it was not until Mr. Binney and others discovered Sigillarian stumps arising from wide-spreading Stigmarian roots that the real relations of the two forms of vegetation were perceived and acknowledged. It is always easy to do a thing after we have been shown how, and so nothing is more common now in all the coal-measures, both of Europe and America, than to find the upright stumps and the subterranean stems still maintaining their original relative positions.

Such, in some particulars, were the Lepidodendrons and Sigillarias of the coal age. The two groups of plants differ widely in some respects, but they are connected by a complete series of intergrading

forms, and in all essential points of structure a close relationship is indicated between them. It is, however, in their relationship with modern plants that they are principally interesting. In the moist woods of New England, and farther south along the summits of the Alleghany Mountains, there lingers a group of little plants, called Lycopods, ground-pines or club-mosses, that must be regarded as the nearest living relatives of Lepidodendron. The habit of growth is very much the same; the mode of fruiting is almost identical; the little spores are produced with the same extravagant copiousness, and, being resinous, are highly inflammable. Both plant and spores—but particularly the latter—will bear long-continued maceration in water without undergoing complete decay; and so it is, in a great many respects, that our little club-mosses—rarely attaining the dignity of a

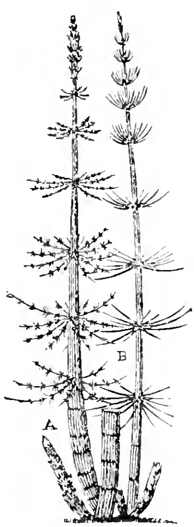

FIG. 10.—RESTORATION OF A CALAMITE.

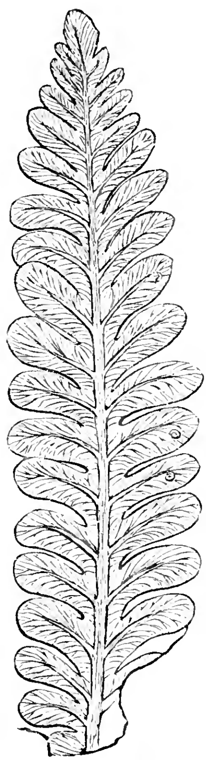

FIG. 11.—COAL-FERN: CALLIPTERIS SULLIVANTI.

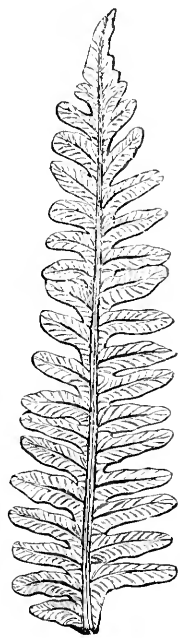

FIG. 12.—COAL-FERN: ALETHOPTERIS MASSILONIS.

foot in height—are very exact miniatures of the ancient Lepidodendrons (Fig. 8). You may then, if you please, call the Lepidodendrons and their allies gigantic club-mosses; and yet, if you do no more than that, you will fall a long way short of doing them full justice. For though in the mode of fruiting they are indeed club-mosses, and

nothing else, yet, as regards other essential structural characters, they deserve a much higher rank. Taking a section of the stem of Sigillaria, for example, and studying the arrangement of the tissues—the pith, wood, bark, and vascular bundles—we find a plan of structure that characterizes only the very highest of modern plants (Fig. 9). Apply the microscope to thin slices, and the most intimate connection with the pines is suggested; indeed, if there were only time, it might be shown that the range of relationship of these old plants extends over a wide section of the vegetable kingdom, and is of such a nature as to set them very much above their dwarfed representatives of the present woods, the club-mosses. In addition to Lepidodendrons and Sigillarias, the forests of the coal age supported many a tall pine, particularly on the uplands, while groves of reed-like calamites (Fig. 10) fringed the swamps; and the whole surface, both of swamp and upland grove, was covered with a dense undergrowth of magnificent ferns (Figs. 11, 12, 13). But the pines were not the pines of our woods, for some of them, through their broad, frond-like leaves and other characters, were allied to ferns, while all of them showed more or less decided taints of characters inherited from club-mosses, or rather the characters were inherited with club-mosses from a common ancestor. The calamites, too, were a curiously mixed-up group, and even the ferns showed a most reprehensible lack of allegiance to the fern type, since most of them united characters that do not belong to ferns at all, but are found now only separated in the palms on the one hand, and the highest flowering plants on the other. It is extremely difficult to present in few words any clear picture of the old Carboniferous forests. The stately club-mosses towering above all competitors—real monarchs of the wood—ornamented from root to crown with beautiful carvings in regular and delicate designs; the magnificent ferns whose exquisite outlines are still preserved in the roof shales of every coal-seam; the dense, dark jungles, tangled and impenetrable; the heavy, steaming, miasmatic atmosphere; the astonishing luxuriance of all the vegetation—these all are themes that claim the attention of every writer or speaker on this subject. But to my mind the prime interest centers in the composite nature of the vegetation, with all its wonderfully puzzling and intricate relationships. He must be dull, indeed, who can not see that in this significant mingling and blending of characters, the old coal forests epitomize and foreshadow all subsequent vegetation. All the structural elements were there; almost every fundamental type had a place in some of the curiously constructed plans of plant-life, and all progress in higher vegetable

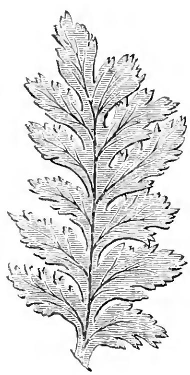

Fig. 13.—Coal-Fern: Hymenophyllitis alatus.

organization since then has come about through the unfolding and development of the possibilities, the carrying out of the promises, and the fulfillment of the prophecies that were woven into every tissue of the old ferns and club-mosses. The types that lay latent in the oldest vegetation have simply been separated and perfected; progressive development has been gradually led along a series of intricate but constantly diverging lines that lead out and up, and finally terminate in the endless graded ranks and profuse varieties which constitute the grand flora—the grandest the world has ever seen—that annually buds and blooms, and bears its wealth of leaf and fruit for you and me, provided only we appreciate it all. Indeed, the whole world, past and present, is ours, but only so far as mind and soul can lay hold of and possess its wondrous beauty, and still more wondrous meaning; beyond that it belongs to the dull ox as much as to us.

But life has never been the exclusive property of plants, at least not since the geological record accessible to us began. Neither have plants monopolized the significant facts from which we may draw interesting conclusions regarding the laws of Nature and of being. In our study of the coal, we catch glimpses of animals that are worthy of notice. Their remains are left, along with the remains of plants, imbedded in the coal itself, or in the strata that limit the coal-seam above and below. Time will permit us to notice only a few examples. We must omit all description of the large, clear-winged insects that flitted in and out among the calamites and ferns, as well as of the curious spiders that laid snares for them in all available places; and we can only mention the scorpions and cockroaches that hid in the chinks and crevices of the fallen pines and club-mosses. All these would be interesting enough if time allowed, and interesting too would be the centipeds and land-snails that Dawson found in hollow Sigillarian stumps of the coal-measures of Nova Scotia. All would tend to enforce the lesson that the world in the Carboniferous age was controlled and operated very much as at present. Trees germinated and grew to perfection and died, and the hollow stumps became the refuge of myriads of creeping things, that found safety from hungry enemies only in complete concealment.

It is to the animals of higher rank that we must give attention. Let us remember that the Carboniferous age comes just after that which witnessed the introduction of fishes—the earliest as well as the lowest of animals having brains, and heads, and spinal columns. It lies, therefore, very near the focus toward which all the genealogical lines of our present vertebrates converge, and hence every structural feature in the higher Carboniferous animals becomes invested with a peculiar interest. Of true fishes there were none—they are a much later product—but, of creatures that combined in the most unthought-of ways the characters of both fish and reptile, the seas seem to have

been full. Fishes of the gar-pike pattern (and yet not like that either, for they were of no one pattern in particular), with lungs far enough developed to enable them to carry on respiration in the air as well as in the water, were on the whole most abundant. In some particulars these creatures stood very low in the scale of fish-life, and yet in others they outranked any fishes with which we are familiar. The curious mixing of class characters produced results always interesting, though sometimes ludicrous. The incongruity of these combinations seems to culminate in that absurd creature, neither one thing nor the other, from the coal-fields of Bavaria, which had the head, gills, backbone, and body generally, of a fish mounted on the limbs of a reptile (Fig. 14). Then there were real reptiles in the forests and coal-marshes; at least there were animals that by way of courtesy we may call reptiles, for they breathed air only, they were provided with true reptilian limbs, and the body was incased in a complete outfit of the

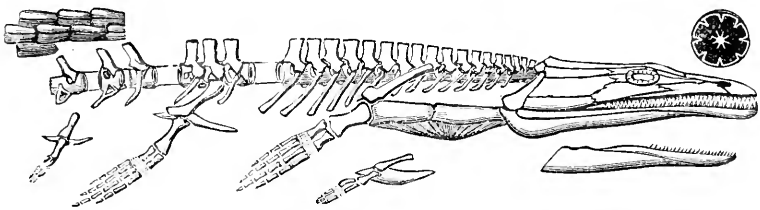

Fig. 14.—Archegosaurus.

most approved reptilian armor. But in some respects they were not reptiles: the skeleton was imperfectly developed; the spinal column was such as belongs, of right, only to fishes; while the head and its articulation with the body, considered alone, would place them with the frog and salamander among the naked amphibians. These reptile-like creatures seem to have divided very early in their history, so as to follow two distinct lines of development: one group of small symmetrical forms, light of foot and swift of motion, frequented the higher portions of the land, and sought its food among the tribes of insects; the other, with strong limbs and jaws, with heavy body and aquatic habit, played the part of crocodiles. Now, these crocodiles were the lords of creation. All the while our coal was forming they stood at the head of created things. Had any human intelligence, with skill to read the geological record of all preceding time, been permitted to look in upon the Carboniferous world, he might well have believed that the end had come. He would have seen evidences of decay in many of the living tribes, and would have noticed that in all the past there were signs and promises and apparent preparations that seemed to point to these very tribes, and particularly to the crocodiles, as the complete realization and fulfillment of all creative designs. His human blindness to the

future would have prevented his seeing any promise beyond. But prophetic indications always become plainer after their fulfillment, and so we, by the aid of all subsequent life-history, are able to read in the structure of the Carboniferous reptiles the promise of better things. As the age draws on to its close, certain characters become more and more pronounced in some of the old, half-formed crocodiles, while a totally different set of peculiarities come to the front in others. Taking the whole group together, we find a very wide range of affinities indicated. One of these points by unmistakable signs to the dinosaurs—great, biped, bird-like reptiles that became conspicuous in the age following the coal. From these the passage is direct to the reptilian birds of the same age, so like dinosaurs in many particulars that they can hardly be distinguished. Then follows, after delay and successive changes of form reaching over geologic periods, the real bird type of our woods and fields, marvelous in its perfect adaptations and marvelous in its perfect symmetry and beauty.

But some of those old reptiles are fraught with suggestions of still higher meaning. In some of the groups recently brought to light from strata that mark the closing epochs of the Carboniferous age, the coming mammal is very plainly indicated. And so, if we only read aright, we may find in our piece of coal the suggestion and the promise of even the highest forms of life.

So it is that we have a very direct interest in that old coal age, an interest altogether independent of the coal itself, even though we know that modern industry and commerce and civilization, and the great centers of human population—the manufacturing and commercial cities, with all their wealth and magnificence—are directly dependent upon its marvelous stores of energy. The physicist will tell us how that energy, which drives our engines, warms and lights our rooms and makes it possible for us to sit here in comfort and never miss the light of the sun to-night, is simply so much force derived from the sunbeams of the Carboniferous age, invested for our benefit in the old ferns and club-mosses ; and yet our interest in the coal rises above all this. The roots of the present strike very deeply into the past, and nothing is risked in saying that, had the Carboniferous age, in its strangely constituted life-forms or in any other regard, been different in ever so small a degree, the present would not be just what it is. It is away back in the coal that we find, not only the promise of the grandly diversified system of vegetable life that lends so much of beauty and interest to the age in which we live ; but it was then, also, that manifest preparations were made for bringing upon the scene the various specialized groups of animals that are to-day a matter of personal concern to every one of us. It was in the coal, too, that we found the first real evident but rude shapings of the organic frame which we ourselves wear. Hugh Miller—an authority that may be safely introduced on this occasion—was accustomed to quote approv-

ingly from Dryden a stanza that to-day has more of meaning, perhaps, than either he or the poet ever perceived:

> "From harmony, from heavenly harmony,
> This universal frame began;
> From harmony to harmony,
> Through all the compass of the notes it ran,
> The diapason closing full in man."

All investigation only adds grander significance to the grand utterance of Agassiz, that "man is the end toward which all the animal creation has tended since the first appearance of the first palæozoic fishes."

Is it not true that "an increasing purpose" does run through the ages by the processes of which, not only "the thoughts of men are widened," but enlarged encouragement is given to all their hopes and expectations of the future?

THE DEVELOPMENT OF POLITICAL INSTITUTIONS.

By HERBERT SPENCER.

V.—POLITICAL FORMS AND FORCES.

THE conceptions of biologists have been greatly advanced by the discovery that organisms which, when adult, appear to have scarcely anything in common, were, in their first stages, very similar; and that, indeed, all organisms start with a common structure. Recognition of this truth has revolutionized not only their ideas respecting the relations of organisms to one another, but also respecting the relations of the parts of each organism to one another.

If societies have evolved, and if that mutual dependence of their parts which social coöperation implies, and which constitutes them organized bodies, has been gradually reached, then the implication is that, however unlike their developed structures become, there is a rudimentary structure with which they all set out. And, if there can be recognized any such primitive unity, recognition of it will help us to interpret the ultimate diversity. We shall understand better how in each society the several components of the political agency have come to be what we now see them, and how those of one society are related to those of another.

Setting out with an unorganized horde, including both sexes and all ages, let us ask what must happen when some question, as that of migration or defense against enemies, has to be decided. The assembled individuals will fall, more or less clearly, into two divisions. The elder, the stronger, and those whose sagacity and courage have

been proved by experience, will form the smaller part, who carry on the discussion, while the larger part, formed of the young, the weak, and the undistinguished, will be listeners, who usually go no further than to express from time to time assent or dissent. A further inference may safely be drawn. In the cluster of leading men there is sure to be some one whose weight is greater than that of any other—some aged hunter, some distinguished warrior, some cunning medicine-man, who will have more than his individual share in forming the resolution finally acted upon. That is to say, the entire assemblage will resolve itself into three parts. To use a biological metaphor, there will, out of the general mass, be differentiated a nucleus and a nucleolus.

These first traces of political structure, which we infer *a priori* must spontaneously arise, we find have arisen among the rudest peoples; repetition having so strengthened them as to produce a settled order. When, among the aborigines of Victoria, a tribe plans revenge on another tribe supposed to have killed one of its members, "a council is called of all the old men of the tribe. . . . The women form an outer circle round the men. . . . The chief [simply 'a native of influence'] opens the council." And what we here see happening in an assemblage having no greater differences than those based on strength, age, and capacity, happens when, later, these natural distinctions have gained definiteness. In illustration may be named the account which Schoolcraft gives of a conference at which the Chippewas, Ottawas, and Pottawattamies, met certain United States commissioners, Schoolcraft being himself present. After the address of the head commissioner had been delivered, the speaking on behalf of the Indians was carried on by the principal chiefs; the lead being taken by "a man venerable for his age and standing." Though Schoolcraft does not describe the assemblage of undistinguished people, yet that they were present is shown by a passage in one of the native speeches: "Behold! see my brethren, both young and old—the warriors and chiefs—the women and children of my nation." And that the political order observed on this occasion was the usual order, is implied by its recurrence even in parts of America where chiefs have become marked off by ascribed nobility; as instance the account quoted by Bancroft of one of the Central American tribes, who "have frequent reunions in their council-house at night. The hall is then lighted up by a large fire, and the people sit with uncovered heads, listening respectfully to the observations and decisions of the *ahuales*—men over forty years of age, who have occupied public positions, or distinguished themselves in some way." Among peoples unlike in type and remote in locality, we find, modified in detail but similar in general character, this primitive governmental form. Of the Hill tribes of India may be instanced the Khonds, of whom we read that "assemblies of the whole tribe, or of any of its subdivisions, are convened, to determine

questions of general importance. The members of every society, however, have a right to be present at *all* its councils, and to give their voices on the questions mooted, although the patriarchs alone take a part in their public *discussion*. . . . The federal patriarchs, in like manner, consult with the heads of tribes, and assemble when necessary the entire population of the federal group."

In New Zealand the government was conducted in accordance with public opinion expressed in general assemblies; and the chiefs "could not declare peace or war, or do anything affecting the whole people, without the sanction of the majority of the clan." Of the Tahitians, Ellis tells us that the king had a few chiefs as advisers, but that no affair of national importance could be undertaken without consulting the land-holders or second rank, and also that public assemblies were held. Similarly of the Malagasy: "The greatest national council in Madagascar is an assembly of the people of the capital, and the heads of the provinces, towns, villages, etc." The king usually presides in person.

Though in these last cases we see considerable changes in the relative powers of the three components, so that the inner few have gained in authority at the expense of the outer many, yet all three are still present; and they continue to be present when we pass to sundry historic peoples. Even of the Phœnicians, Movers notes that "in the time of Alexander a war was decided upon by the Tyrians without the consent of the absent king, the senate acting together with the popular assembly." Then there is the familiar case of the Homeric Greeks, whose Agora, presided over by the king, was "an assembly for talk, communication and discussion to a certain extent by the chiefs, in presence of the people as listeners and sympathizers," who were seated around; and that the people were not always passive is shown by the story of Thersites, who, ill-used though he was by Odysseus and derided by the crowd for interfering, had first made his harangue. Again, the king, the senate, and the freemen, in primitive Rome, stood in relations which had manifestly grown out of those existing in the original assembly; for, though the three did not simultaneously coöperate, yet on important occasions the king communicated his proposals to the assembled burgesses, who expressed their approval or disapproval, and the clan-chiefs, forming the senate, though they did not debate in public, had yet such joint power that they could, on occasion, negative the decision of king and burgesses. Concerning the primitive Germans, Tacitus, as translated by Mr. Freeman, writes: "On smaller matters the chiefs debate, on greater matters all men; but so that those things whose final decision rests with the whole people are first handled by the chiefs. . . . The multitude sits armed in such order as it thinks good; silence is proclaimed by the priests, who have also the right of enforcing it. Presently the king or chief, according to the age of each, according to his birth,

according to his glory in war or his eloquence, is listened to, speaking rather by the influence of persuasion than by the power of commanding. If their opinions give offense, they are thrust aside with a shout; if they are approved, the hearers clash their spears."

Similarly among the Scandinavians, as shown us in Iceland, where, besides the general Al-thing annually held, which it was "disreputable for a freeman not to attend," and at which "people of all classes in fact pitched their tents," there were local assemblies called Var-things "attended by all the freemen of the district, with a crowd of retainers . . . both for the discussion of public affairs and the administration of justice. . . . Within the circle [formed for administering justice] sat the judges, the people standing on the outside." In the account given by Mr. Freeman of the yearly meetings in the Swiss cantons of Uri and Appenzell, we may trace this primitive political form as still existing; for though the presence of the people at large is the fact principally pointed out, yet there is named, in the case of Uri, the body of magistrates or chosen chiefs who form the second element, as well as the head magistrate who is the first element. And that in ancient England there was a kindred constitution of the Wittenagemót, is indirectly proved; as witness the following passage from Freeman's "Growth of the English Constitution": "No ancient record gives us any clear or formal account of the constitution of that body. It is commonly spoken of in a vague way as a gathering of the wise, the noble, the great men. But, alongside of passages like these, we find other passages which speak of it in a way which implies a far more popular constitution. King Eadward is said to be chosen king by 'all folk.' Earl Godwine 'makes his speech before the king and all the people of the land.'" And the implication, as Mr. Freeman points out, is that the share taken by the people in the proceedings was that of expressing by shouts their approval or disapproval.

This form of ruling agency is thus shown to be the fundamental form, by its presence at the outset of social life and by its continuance under various conditions. Not among peoples of superior types only, such as Aryans and some Semites, do we find it, but also among sundry Malayo-Polynesians, among the red men of North America, the Dravidian tribes of the Indian hills, the aborigines of Australia. In fact, as already implied, governmental organization could not possibly begin in any other way. On the one hand, no controlling force at first exists save that of the aggregate will as manifested in the assembled horde. On the other hand, leading parts in determining this aggregate will are inevitably taken by the few whose superiority is recognized. And of these predominant men some one is sure to be most predominant. That which we have to note as specially significant, is not that a free form of government is the primitive form; though this is an implication which may be dwelt upon. Nor are we chiefly concerned with the fact that at the very beginning there

shows itself that separation of the superior few from the inferior many, which becomes marked in later stages; though this, too, is a fact which may be singled out and emphasized. Nor is attention to be mainly directed to the early appearance of a controlling head, having power greater than that of any other; though the evidence given may be cited to prove this. But here we have to note, particularly, the truth that at the very outset may be discerned the vague outlines of a triune political structure.

Of course, the ratios among the powers of these three components are in no two cases quite the same; and, as implied in sundry of the above examples, they everywhere undergo more or less change—change determined here by the emotional natures of the men composing the group, there by the physical circumstances as favoring or hindering independence, now by the activities as warlike or peaceful, and now by the exceptional characters of particular individuals.

Unusual sagacity, skill, or strength, habitually regarded by primitive men as supernatural, may give to some member of the tribe an influence which, transmitted to a successor supposed to inherit his supernatural character, may generate a chiefly authority subordinating both that of the other leading men and that of the mass. Or a division of labor, such that while some of the tribe remain exclusively warriors the rest are in a measure otherwise occupied, may give to the two superior components of the political agency an ability to override the third. Or the members of the third, keeping up habits which make coercion of them difficult or impossible, may maintain a general predominance over the other two. And then the relations of these three governing elements to the entire community may, and ordinarily do, undergo change by the formation of a passive class, excluded from their deliberations—a class at first composed of the women and afterward containing also the slaves or other dependents.

War, successfully carried on, not only establishes the passive or non-political class, but also, implying as it does subordination, changes more or less decidedly the relative powers of these three parts of the political agency. As, other things equal, groups in which there is little or no subordination are subjugated by groups in which subordination is greater, there is a tendency to the survival and spread of groups in which the controlling power of the dominant few becomes relatively great. In like manner, since success in war largely depends on that promptitude and consistency of action which singleness of will gives, there must, where warfare is chronic, be a tendency for members of the ruling group to become more and more obedient to its head: disappearance in the struggle for existence, among tribes otherwise equal, being ordinarily a consequence of inadequate obedience. And then it is also to be noted that the overrunnings of societies one by another, repeated and re-repeated as they often are, have the effect

of obscuring and even obliterating the traces of the original political form.

While, however, recognizing the fact that during political evolution these three primitive components alter their proportions in various ways and degrees, to the extent that some of them become mere rudiments or wholly disappear, it will greatly alter our conception of political forms if we remember that they are all derived from this primitive form—that a despotism, an oligarchy, or a democracy, is to be regarded as a type of government in which one of the original components has greatly developed at the expense of the other two, and that the various mixed types are to be arranged according to the degrees in which one or other of the original components has the greater influence.

Is there any fundamental unity of political forces accompanying this fundamental unity of political forms? While losing sight of the common origin of political structures, have we not also become inadequately conscious of the common source of their powers? How prone we are to forget the ultimate, while thinking of the proximate, it may be worth while pausing a moment to observe.

One, who in a storm watches the breaking-up of a wreck or the tearing down of a sea-wall, is impressed by the immense energy of the waves. Of course, when it is pointed out that in the absence of wind no such results can be produced, he recognizes the truth that the sea is in itself powerless, and that the power enabling it to destroy vessels and piers is given by the currents of air which roughen its surface. If he stops short here, however, he fails to identify the force which works these striking changes. Intrinsically, the air is just as passive as the water is. There would be no winds were it not for the varying effects of the sun's heat on different parts of the earth's surface. Even when he has traced back thus far the energy which undermines cliffs and makes shingle, he has not reached its source; for in the absence of that continuous concentration of the solar mass, caused by the mutual gravitation of its parts, there would be no solar radiations.

The tendency here illustrated, which all have in some degree and most in a great degree, to associate power with the visible agency exercising it, rather than with its inconspicuous source, has, as above implied, a vitiating influence on conceptions at large, and among others on political ones. Though the habit, general in past times, of regarding the powers of governments as inherent, has been, by the growth of popular institutions, a good deal qualified; yet, even now, there is no clear apprehension of the fact that governments are not themselves powerful, but are the instrumentalities of a power. This power existed before governments arose; governments were themselves produced by it; and it ever continues to be that which, disguised more or less completely, works through them. Let us go back to the beginning.

The Greenlanders are entirely without political control; having nothing which represents it more nearly than the deference paid to the opinion of some old man, skilled in seal-catching and the signs of the weather. But a Greenlander who is aggrieved by another has his remedy in what is called a singing combat. He composes a satirical poem, and challenges his antagonist to a satirical duel in face of the tribe: "He who has the last word wins the trial." And then Crantz adds: "Nothing so effectually restrains a Greenlander from vice as the dread of public disgrace." Here we see operating, in its original unqualified way, that governing influence of public sentiment which precedes more special governing influences. The dread of social reprobation is in some cases enforced by the dread of banishment. Among the otherwise unsubordinated Australians, they "punish each other for such offenses as theft, sometimes by expulsion from the camp." Of one of the Columbian tribes we read that "the Salish can hardly be said to have any regular form of government"; and then, further, we read that "criminals are sometimes punished by banishment from their tribe." Certain aborigines of the Indian hills, widely unlike these Columbians in type and in their modes of life, show us a similar relation between undeveloped political restraint and the restraint of aggregate feeling. Among the Bodo and Dhimáls, whose village heads are simply respected elders with no coercive power, those who offend against customs "are admonished, fined, or excommunicated, according to the degree of the offense." But the controlling influence of public sentiment, in groups which have little or no political organization, is best shown in the force with which it acts on those who are bound to avenge murders. Concerning the Australian aborigines, Sir George Grey writes: "The holiest duty a native is called on to perform is that of avenging the death of his nearest relation, for it is his peculiar duty to do so; until he has fulfilled this task, he is constantly taunted by the old women; his wives, if he is married, would soon quit him; if he is unmarried, not a single young woman would speak to him; his mother would constantly cry, and lament that she should ever have given birth to so degenerate a son; his father would treat him with contempt, and reproaches would constantly be sounded in his ear."

We have next to note that, for a long time after political control has made its appearance, it remains conspicuously subordinate to this control of general feeling; both because, while there is no developed political organization, the head-man has little ability to enforce his will, and because such ability as he has, if unduly exercised, causes desertion. From all parts of the world may be cited illustrations. In America, among the Snake Indians, "each individual is his own master, and the only control to which his conduct is subjected is the advice of a chief supported by his influence over the opinions of the rest of the tribe." Of a Chinook chief we are told that "his ability

to render service to his neighbors, and the popularity which follows it, is at once the foundation and the measure of his authority." If a Dakota "wishes to do mischief, the only way a chief can influence him is to give him something, or pay him to desist from his evil intentions. The chief has no authority to act for the tribe, and dare not do it." And among the Creeks, more advanced in political organization though they are, the authority of the elected chiefs "continues during good behavior. The disapproval of the body of the people is an effective bar to the exercise of their powers and functions." Turning to Asia, we read that the *bais* or chiefs of the Kirghiz "have little power over them for good or evil. In consideration of their age and blood, some deference to their opinions is shown, but nothing more." The Ostiaks "pay respect, in the fullest sense of the word, to their chief, if wise and valiant, but this homage is voluntary, and founded on personal regard." And of the Naga chiefs Butler says, "Their orders are obeyed so far only as they accord with the wishes and convenience of the community." So too is it in parts of Africa; as instance the Koranna Hottentots: "A chief or captain presides over each clan or *kraal*, being usually the person of greatest property; but his authority is extremely limited, and only obeyed so far as it meets the general approbation." And even among the more politically organized Caffres, there is a kindred restraint. The king "makes laws and executes them according to his sole will. Yet there is a power to balance his in the people: he governs only so long as they choose to obey." They leave him if he governs ill.

In its primitive form, then, political power is the feeling of the community, acting through an agency which it has either informally or formally established. Doubtless, from the beginning, the power of the chief is in part personal: his greater strength, courage, or cunning, enables him in some degree to enforce his individual will. But, as the evidence shows, his individual will is but a small factor; and the authority he wields is proportionate to the degree in which he expresses the wills of the rest.

While this public feeling, which first acts by itself and then partly through an agent, is to some extent the feeling spontaneously formed by those concerned, it is to a much larger extent the opinion imposed on them or prescribed for them. In the first place, the emotional nature prompting the general mode of conduct is derived from ancestors, being a product of all past activities; and, in the second place, the special motives which, directly or indirectly, determine the courses pursued, are induced during early life by seniors, and enlisted on behalf of beliefs and usages which the tribe inherits. The governing sentiment is, in short, mainly the accumulated and organized sentiment of the past.

It needs but to remember the mutilation to which, at a prescribed

age, each member of a tribe is subject—the knocking out of teeth, the gashing of the flesh, the tattooing, the submission to torture—it needs but to remember that from these imperative customs there is no escape, to see that the directive force which exists before political agency arises, and which afterward makes the political agency its organ, is the gradually formed opinion of countless preceding generations; or rather, not the opinion, which, strictly speaking, is an intellectual product wholly impotent, but the emotion associated with the opinion. This we everywhere find to be at the outset the chief controlling power.

The notion of the Tupis, that, "if they departed from the customs of their forefathers, they should be destroyed," may be named as a definite manifestation of the force with which this transmitted opinion acts. In one of the rudest tribes of the Indian hills, the Juángs, less clothed even than Adam and Eve are said to have been, the women long adhered to their bunches of leaves in the belief that change was wrong. Of the Koranna Hottentots we read that, "when ancient usages are not in the way, every man seems to act as is right in his own eyes." Though the Damara chiefs "have the power of governing arbitrarily, yet they venerate the traditions and customs of their ancestors." Smith says, "Laws the Araucanians can scarcely be said to have, though there are many ancient usages which they hold sacred and strictly observe." According to Brooke, among the Dyaks custom simply seems to have become the law, and breaking of the custom leads to a fine. In the minds of some clans of the Malagasy, "innovation and injury are . . . inseparable, and the idea of improvement altogether inadmissible."

This control by inherited usages is not simply as strong in groups of men who are politically unorganized, or but little organized, as it is in advanced tribes and nations, but it is stronger. As Sir John Lubbock remarks: "No savage is free. All over the world his daily life is regulated by a complicated and apparently most inconvenient set of customs (as forcible as laws), of quaint prohibitions and privileges." Though one of these rude societies appears to be structureless, yet its ideas and usages form a kind of invisible framework for it, serving rigorously to restrain certain classes of its actions. And this invisible framework has been slowly and unconsciously shaped, during daily activities impelled by prevailing feelings and guided by prevailing thoughts, through generations stretching back into the far past.

In brief, then, before any definite agency for social control is developed, there exists a control arising partly from the public opinion of the living and more largely from the public opinion of the dead.

But now let us note definitely a truth implied in some of the illustrations above given—the truth that, when a political agency has been evolved, its power, largely dependent on present public opinion, is

otherwise almost wholly dependent on past public opinion. The ruler, in part the organ of the wills of those around, is in a still greater degree the organ of the wills of those who have passed away; and his own will, much restrained by the first, is still more restrained by the last.

For his function as regulator is mainly that of enforcing the inherited rules of conduct which embody ancestral sentiments and ideas. Everywhere we are shown this. Among the Arafuras, such decisions as are given by their elders are "according to the customs of their forefathers, which are held in the highest regard." So is it with the Kirghiz: "The judgments of the *bais*, or esteemed elders, are based on the known and universally recognized customs." And in Sumatra "they are governed in their various disputes by a set of long-established customs (*adat*), handed down to them from their ancestors. . . . The chiefs, in pronouncing their decisions, are not heard to say, 'So the law directs,' but 'Such is the custom.'"

As fast as orally-preserved custom passes into written law, the political head becomes still more clearly an agent through whom the feelings of the dead control the actions of the living. That the power he exercises is mainly a power which acts through him, we see clearly on noting how little ability he has to resist it if he wishes to do so. His individual will is practically inoperative save where the overt or tacit injunctions of departed generations leave him free. Thus, in Madagascar, "in cases where there is no law, custom, or precedent, the word of the sovereign is sufficient." Among the East Africans, "the only limit to the despot's power is the *ada*, or precedent." Of the Javans, Raffles writes, "The only restraint upon the will of the head of the government is the custom of the country, and the regard which he has for his character among his subjects." In Sumatra the people "do not acknowledge a right in the chiefs to constitute what laws they think proper, or to repeal or alter their ancient usages, of which they are extremely tenacious and jealous." And how imperative is this conformity to the beliefs and sentiments of progenitors is shown by the fatal results apt to occur from disregarding them. "'The King of Ashantee, although represented as a despotic monarch, . . . is not in all respects beyond control.' He is under 'an obligation to observe the national customs, which have been handed down to the people from remote antiquity; and a practical disregard of this obligation, in the attempt to change some of the customs of their forefathers, cost Osai Quamina his throne.'" Which instance reminds us how commonly, as now among the Hottentots, as in the past among the ancient Mexicans, and as throughout the histories of civilized peoples, rulers have engaged, on succeeding to power, not to change the established order.

Doubtless the proposition that the political head, simple or compound, is in the main but an agency through which works the force

of public feeling, present and past, seems at variance with the many facts showing how great may be the power of a ruling man himself. Saying nothing of a tyrant's ability to take lives for nominal reasons or none at all, to make groundless confiscations, to transfer subjects bodily from one place to another, to exact contributions of money and labor without stint, we are apparently shown by his ability to begin and carry on wars which sacrifice his subjects wholesale, that his single will may override the will of the nation. In what way, then, must the original statement be qualified?

While holding that, in unorganized groups of men, the feeling manifested as public opinion controls political conduct, just as it controls the conduct distinguished as ceremonial and religious; and, while holding that governing agencies, during their early stages, are at once the products of aggregate feeling, derive their powers from it, and are restrained by it, we must admit that these primitive relations become complicated when, by war, small groups are compounded and recompounded into great ones. Where the society is largely composed of subjugated people held down by superior force, the normal relation above described no longer exists. We must not expect to find, in a rule coercively established by an invader, the same traits as in a rule that has grown up from within. Societies formed by conquest may be, and frequently are, composed of two societies, which are in large measure, if not entirely, alien; whence it results that there is no longer anything like such united feeling as can embody itself in a political force derived from the whole community. Under such conditions the political head either derives his power exclusively from the feeling of the dominant part of the community, or else, setting the diverse masses of feeling originated in the upper and lower societies one against the other, is enabled so to make his individual will the chief factor.

After making which qualifications, however, it may still be contended that, ordinarily, nearly all the force exercised by the governing agency originates from the feelings, if not of the whole community, yet of the part which is able to manifest its feelings. Though the opinion of the subjugated and unarmed lower society becomes of little account as a political factor, yet the opinion of the dominant and armed part continues to be the main cause of political action. What we are told of the Congo people, that "the king who reigns as a despot over the people is often disturbed in the exercise of his power, by the princes his vassals"—what we are told of the despotically-governed Dahomans, that "the ministers, war-captains, and fetichers may be, and often are, individually punished by the king: collectively they are too strong for him, and without their cordial coöperation he would soon cease to reign"—is what we recognize as having been true, and as being still true, in various better-known societies, where the power of the supreme head is nominally absolute. From the time when the Roman emperors were chosen by the soldiers and slain when they did

not please them, to the present time, when, as we are told of Russia, the desire of the army often determines the will of the Czar, there have been many illustrations of the truth that an autocrat is politically strong or weak according as many or few of the influential classes give him their support; and that even the sentiments of those who are politically prostrate greatly affect the political action: instance the influence of Turkish fanaticism over the decisions of the Sultan.

A number of facts must be remembered if we are rightly to estimate the power of the aggregate will in comparison with the power of the autocrat's will. There is the fact that the autocrat is obliged to respect and maintain the great mass of institutions and laws produced by past sentiments and ideas, which have acquired a religious sanction; so that, as in ancient Egypt, dynasties of despots live and die and leave the social order essentially unchanged. There is the fact that a serious change of the social order, at variance with general feeling, is likely afterward to be reversed, as when, in Egypt, Amenhotep IV, spite of a rebellion, succeeded in establishing a new religion, which was abolished in a succeeding reign; and there is the allied fact that laws much at variance with the general will prove abortive, as, for instance, the sumptuary laws made by mediæval kings, which, continually reënacted, continually failed. There is the fact that, supreme as he may be, and divine as the nature ascribed to him, the all-powerful king is yet shackled by usages which often make his daily life a slavery; the opinions of the living oblige him to fulfill the dictates of the dead. There is the fact that if he does not conform, or if he otherwise produces by his acts much adverse feeling, his servants, civil and military, refuse to act, or turn against him; and in extreme cases there comes an example of "despotism tempered by assassination." And there is the further fact that habitually, in societies where an offending autocrat is from time to time removed, another autocrat is set up; the implication being that the average sentiment is of a kind which not only tolerates but desires autocracy. That, which is by some called loyalty and by others servility, both creates the absolute ruler and gives him the power he exercises.

But the cardinal truth, difficult adequately to appreciate, is that, while the forms and laws of each society are the consolidated products of the emotions and ideas of those who have lived throughout the past, they are made operative by the subordination of existing emotions and ideas to them. We are familiar with the thought of "the dead hand" as controlling the doings of the living in the uses made of property; but the effect of "the dead hand," in ordering life at large through the established political system, is immeasurably greater. That which, from hour to hour, in every country, governed despotically or otherwise, produces the obedience making political action possible, is the accumulated and organized sentiment felt toward inherited institutions, made sacred by tradition. Hence it is undeniable that, taken in its

widest acceptation, the feeling of the community is the sole source of political power; in those communities, at least, which are not under foreign domination. It was so at the outset of social life, and it still continues substantially so.

It has come to be a maxim of science that in the causes still at work are to be identified the causes which, similarly at work during past times, have produced the state of things now existing. Acceptance of this maxim and pursuit of the inquiries suggested by it lead to verifications of the foregoing conclusions.

For day after day, every public meeting illustrates afresh this same differentiation characterizing the primitive political agency, and illustrates afresh the actions of its respective parts. There is habitually the great body of the less distinguished, forming the audience, whose share in the proceedings consists in expressing approval or disapproval, and saying ay or no to the resolutions proposed. There is the smaller part, occupying the platform—the men whose wealth, position, or capacity gives them influence—the local chiefs by whom the discussions are carried on. And there is the chosen head, commonly the man of greatest mark to be obtained, who exercises a recognized power over speakers and audience—the temporary king. Even an informally summoned assemblage soon resolves itself into these divisions more or less distinctly; and when the assemblage becomes a permanent body, as of the men composing a commercial company, or a philanthropic society, or a club, definiteness is quickly given to the three divisions—president or chairman, board or committee, proprietors or members. To which add that, though at first, like the meeting of the primitive horde or the modern public meeting, one of these permanent associations, voluntarily formed, exhibits a distribution of powers such that the select few and their head are subordinate to the mass; yet, as circumstances determine, the proportions of the respective powers usually change more or less decidedly. Where the members of the mass are not only much interested in the transactions, but are so placed that they can easily coöperate, they hold in check the select few and their head; but, where wide distribution, as of railway shareholders, hinders joint action, the select few become, in large measure, an oligarchy, and out of the oligarchy there not unfrequently grows an autocrat: the constitution becomes a despotism tempered by revolution.

In saying that from hour to hour proofs occur that the force possessed by a political agency is derived from aggregate feeling, partly embodied in the consolidated system which has come down from the past, and partly excited by immediate circumstances, I do not refer only to the proofs that among ourselves governmental actions are habitually thus determined, and that the actions of all minor bodies, temporarily or permanently incorporated, are thus determined. I refer, rather, to the illustrations of the irresistible control exercised by

average sentiment and opinion over conduct at large. Such facts as that, while public opinion is in favor of dueling, law fails to prevent it, and that sacred injunctions, backed by threats of damnation, are powerless to check the most iniquitous aggressions when the prevailing interests and passions prompt them, alone suffice to show that legal codes and religious creeds, with the agencies enforcing them, are impotent in face of an adverse sentiment. On remembering the eagerness for public applause and the dread of public disgrace which stimulate and restrain men, we can not question that the diffused manifestations of feeling habitually dictate their careers when their immediate necessities have been satisfied. It requires only to contemplate the social code which regulates life down even to the color of an evening necktie, and to note how those who dare not break this code have no hesitation in smuggling, to see that an unwritten law enforced by opinion is more peremptory than a written law not so enforced. And still more on observing that men disregard the just claims of creditors, who for goods given can not get the money, while they are anxious to discharge so-called debts of honor to those who have rendered neither goods nor services, we are shown that the control of prevailing sentiment, unenforced by law and religion, may be more potent than law and religion together when they are backed by sentiment less strongly manifested. Looking at the total activities of men, we are obliged to admit that they are still, as they were at the outset of social life, guided by the aggregate feeling, past and present; and that the political agency, itself a gradually-developed product of such feeling, continues still to be in the main the vehicle for a specialized portion of it, regulating actions of certain kinds.

Partly, of course, I am obliged here to set forth this general truth as an essential element of political theory. My excuse for insisting at some length on what appears to be a trite conclusion must be, that, however far nominally recognized, it is actually recognized to a very small extent. Even in our own country, where non-political agencies spontaneously produced and worked are many and large, and still more in most other countries less characterized by them, there is no due consciousness of the truth that the combined impulses which work through political agencies can, in the absence of such agencies, produce others through which to work. Politicians reason as though state-instrumentalities have intrinsic power, which they have not, and as though the feeling which creates them has not intrinsic power, which it has. Evidently their actions must be greatly affected by reversal of these ideas.

LINGERING BARBARISM.

TRANSLATED FROM THE GERMAN OF CARL VOGT BY A. R. MACDONOUGH.

THE striking feature of the present age is that outcropping of barbarism which has found in the persecution of the Jews an object for the full exercise of its passionate violence. It is our inheritance of centuries, hard to conquer, enduring as adamantine substance in those races that worked themselves out later than the rest into an existence worthy of man. Spite of all contradiction, I hold fast to this view, because it is true in its inmost core.

Just as an organism evolves, out of two mutually hostile tendencies, inheritance of character derived from ancestry, and acquirement of new advantages in the struggle for life through adjustment to its environment, so the special nature of a people builds itself up out of the inheritance bequeathed by its forefathers and the conquests it has won for itself in its contest for being. In a people's life, as in the individual's life, there are times when the one or the other of these striving forces steps into the foreground and thrusts the other back. Development does not advance with even flow, but by fits and starts—oftenest it is like that style of march in which two leaps are made backward after taking three forward.

We do leap—but it is backward, away into the middle ages, which we fancied we had got rid of.

The sign and token of our time contrasted with the middle ages is knowledge in contrast to belief ; the exact method of research opposed to the sway of usurped authority; the free movement of forces all over the globe, as against limitation within narrow bounds and spaces; the peaceful, harmonious working of the nations toward high humane ends, as against their hostile rivalry to the end of subjection and ravage ; the recognition of common human rights, as against the special claims of isolated castes and ranks. Whatever domain of political life we regard, we note everywhere the same tendency toward that reactionary groping after our inheritance from the middle ages.

Nor is this strange. One who clears his eyes from that whirlwind dust of glory flung abroad by warlike violence, and pictures pure fact to himself, sees that all its substantial results are due only to the systematic development and perfecting of material strength and power. He must logically come to the conclusion that the plant which has been so carefully nurtured and trained to the most vigorous productiveness can not wither down to its very root after this energetic effort. Victory always brings intoxication, and in its paroxysm those spirits are unchained which a sober and quiet life had fettered in the bonds of discretion. We insist on enjoying to the full the inheritance till now only partly spent.

Is it a matter for surprise, then, that Jewish persecution has found a foothold in the universities, among boys at their studies; that this German youth hurrahs for Treitschke, that Slavonic sprout, with his exclusive German utterances; or that their trainers in classics need to be reminded of good morals by paying them in the same coin they use to enlighten the babes and sucklings committed to their care?

Why should these boy-pupils, these buff-jerkined and jack-booted swaggerers, ingrained and inwrought in their very baby natures with the notion of distinction in ranks, not fall upon the "old-clo' peddler fellows," and all the more savagely because these dare to aim at becoming their rivals? How can one expect them to be just to descendants of an alien race, when it has been preached and crammed into them, from their breech-clout days, that the world's weal depends on their race alone; that their seed alone is called to lordship; and that all other nations in their rottenness are intended for nothing else but for service as their subjects and self-sacrifice to their mastery?

The root of the matter lies very much deeper. The world of antiquity, on which the education of our youth has been nourished since the middle ages, and is fed now, was founded on the institution of slavery; its whole existence would be as inconceivable apart from slavery as would be the aboriginal German world without woman's servile labor for her lazy lord and husband. The ancient German Tacitus drew was a hunter and fighter, stretched at odd times on his bear-skin, guzzling and gambling, while his Thusneldas and serfs did all the work for him, tilling the ground and sweating for his food. That was the German civilization which our students chant in their songs; and its traces are the tattoo-scars across their faces, of which they are so proud, though these are mere proofs of clumsiness, not signs of dangers met.

All the cultivation of the middle ages rested on so-called classical studies, which are bound up in the closest relations with barbarous and violent use of power. The Spanish mock stateliness of mediæval scholasticism is indivisible from the savagery of mediæval university life, and we have accepted it in these modern days along with the rest of our inheritance, and find it cherished and protected in our universities by the powers that be.

Our age strives and struggles for the recognition of the exact sciences which have thoroughly penetrated our life, as opposed to those systems of so called humanist education handed down to us from the middle ages. Unresting, unfaltering, exact science presses forward with its methods and results. It feeds and clothes us, multiplies our means of intercourse, controls our whole political and domestic economy, masters our thought and our feeling, and daily wins us new fruits of good in the struggle for existence. It knows no distinctions of peoples, castes, and nations; no qualification of territory or geographical restriction. There is no such thing as German steam-power,

or Semitic electricity, or Roman magnetism; it bids any and every people welcome that will promote science and lend it help.

When we remember that the natural sciences began only about a century ago to strive for a place in the state; that before that date they had been nothing more than the private affair of exceptional minds; that for the first half of our century even they played absolutely no part in public education, but only ran a tolerated subcourse with it in the universities, and were utterly unnoticed both in the lower schools and in special seminaries; that in my younger days a man might be regarded as cultivated without having the faintest notion of any natural science whatever; and that it was made a reproach to men like Goethe that they took any interest in the sciences, and showed an active concern about them—when we think of all this, and compare with it the circumstances of our day, and the tendencies of our times, we understand at once why those authorities who would step backward into bygone ages prefer so-called classical education and favor all the influences that have clung to it since mediæval days—why they would restore to the word that authority which is claimed to-day by the fact, and why those who are still paddling about in that cultivation, handed down to us from the middle ages, seize on every straw they fancy able to keep them above water. An instinct tells these half-taught noodles that the ground is slipping away from them; that a day is rapidly drawing near when those branches of knowledge, which they assert as of universal need for every man who claims to be cultivated, shall be worthless except as specialities; when only one here and there will trouble himself about whether some crowned cowherd marched with his mates on a plundering slave-hunt, as in Homer's times; and when the knowledge of Nature and her laws must come to the front as always indispensable to a liberal education. Just as that man, a century or so ago, was looked on as wholly neglected and uneducated who had not toiled at his school-desk over the scanning of Latin verses, so will people no long time hence be surprised at the careless lack of training in that man who has not mastered the mechanism of the telegraph or the laws of heat long before he takes his way to the university.

"My good man," wrote a Hessian landgrave at the beginning of the last century to his postmaster, who had cudgeled a royal messenger—"my good man, we have heard with the highest displeasure the steps you have presumed on in your inborn coarseness and clownishness." I don't know whether the Landgrave laid great stress on the word "inborn," but he certainly used it with the feeling that the case was one of inherited peculiarity. Now, in that day classical education held sole and undisputed rule; could it have pushed back heredity and stifled it by nobler growths?

Most surely not; and what classical training could not avail to do in centuries when it held sole sway, it is still more powerless to effect

now that a rival has grown up beside it which it never through all time can prevail against.

While writing this, a pamphlet is sent me by a friend, entitled "Secession—Berlin, Julius Springer, 1881," in which the anonymous but certainly very intelligent author questions our political and financial conditions from his point of view. While this pamphlet is highly remarkable, as well for its contents as for its way of expressing them, it is perhaps yet more remarkable for that which it either hints or leaves unsaid—I mean, to speak plainly, for its indulgence toward that easy-going confidence with which some of the eminent minds of the past ten years have allowed themselves to believe that the whole nature of mankind is radically changed, because it has walked for a while with a varnished cane instead of a knotty club. I find in it an agreement with my doctrine partly gratifying and partly saddening, since I can hardly understand how an author of so much insight should not long ago have felt the scales drop from his eyes. "Wherever our glance falls," he says, "nothing strikes us but ideas, laws, institutions, that existed a century ago, and yet have been set aside for ten years past or more, by the course of culture and increasing insight. Reaction toward restrictions on our trade with foreigners followed by restrictions on domestic trade; next, fetters on personal liberty and freedom of action; then, backward steps to the stern penal codes of past ages, and to the proscriptive and coercive laws of a patriarchal world. The whole contrivance, piece by piece, is borrowed and brought out from the rusty arsenal of the good old times. Whatever is now devised is dug up from the deep and ever-deeper dust of centuries."

It is even so. Yet it may, perhaps, be said that, with a little less classical and philosophical training, and a little more education in natural science, it would probably earlier have become evident that, even without wishing or intending it, we were taking an active part in this disinterment from the dust of centuries. At all events, it is well that this conviction is now forcing its way: it is only to be hoped that it may gain clearer reality and wider range in those who have won it.

These things, however, press with light weight in the scales of the future, how lamentable soever they may be in the present. Whether a reactionary law the more or the less be made, whether the secessionists thrive or perish, it is of course a pitiable sign of the times that the student body here roar with applause at their hero gabbler Treitschke, there pledge themselves to the Jewish persecution, and raise dueling squabbles about it—a sign hardly compensated for by the indignation with which the cities kick Chaplain Stöcker's nauseous double-faced hypocrisy out of doors. But this does not touch the root of the matter, which lies in the training of our youth in increasing waste-paper scribblings and reactionary barbarism. Not much improvement can be hoped for in the present generation; we may check and repress,

if we choose, the manifestations of their indwelling brutality, but can not hinder its secret permanence, amazing as such impulses seem to close observers. But all who are seriously devoted to progress may keep this truth fixed in view, that all elevation of classical studies at the expense of other branches of knowledge is a step backward into barbarism, and all furtherance of the exact sciences in the teaching of youth is a step forward toward civilization.

And, in this connection, I find great satisfaction in drawing attention to the address delivered at the opening of the Mason Science College, at Birmingham, by Huxley, the distinguished English scientist, and published in the number of "Nature" for October 7, 1880.

It seems that there arose in the mind of Sir Josiah Mason, an Englishman, apparently a money-getter of the purest type, the idea, certainly a most extraordinary one, of spending in his lifetime thousands of pounds, not in buying Krupp guns, but in establishing at Birmingham an amply endowed college, in which young persons might acquire "sound, extensive, and practical scientific knowledge." The founder of this institute leaves its managers all possible freedom as to the means for attaining this object, only binding teachers and pupils alike for all coming time in three particulars: Party politics of whatever nature are excluded; theology is shown the door once for all; and, in conclusion, it is expressly prescribed that the college shall make no provision for mere literary instruction and education.

There was something that did not occur to the mind of this Englishman, enriched by trade and industry, who felt that every step in his path of life was almost a stumble, by reason of his defective knowledge of the exact sciences. "It is not impossible," says Huxley, "that we shall hear this express exclusion of 'literary instruction and education' from a college which nevertheless professes to give a high and efficient education sharply criticised. Certainly the time was that the Levites of culture would have sounded their trumpets against its walls as against an educational Jericho."

The time has come, indeed, and the storm of indignation that arose, among the Levites of classical old England, is still echoing in the newspapers—a storm bursting not over the college alone, but specially over Huxley, so eminent in science, who dared in the course of his address to vindicate this idea.

"For those," he says, "who mean to make science their serious occupation, or who intend to follow the profession of medicine, or who have to enter early upon the business of life—for all these, in my opinion, classical education is a mistake; and it is for that reason that I am glad to see 'mere literary instruction and education' shut out from the curriculum of Sir Josiah Mason's college, seeing that its inclusion would probably lead to the introduction of the ordinary smattering of Latin and Greek. Nevertheless, I am the last person to question the importance of genuine literary education, or to suppose

that intellectual culture can be complete without it. An exclusively scientific training will bring about a mental twist as surely as an exclusive literary training. The value of the cargo does not compensate for the ship's being out of trim; and I should be very sorry to think that this scientific college would turn out none but lop-sided men. There is no need, however, that such a catastrophe should happen. Instruction in English, French, and German is provided, and thus the three greatest literatures of the world are made accessible to the student."

Such is the way of it under the government of the classical Homer-student, Gladstone! An Englishman, who is master of only three living languages and the exact sciences, is held to be as highly cultivated as a barrister who understands only English and some Latin and Greek, but has steered his way cleverly through Oxford or Cambridge!

But fancy for a moment that it should occur to the mind of some opulent Jew (such an idea surely would never strike a Christian German) to found such a "Mason's College" in Germany, on the plan of "no religious teaching, no politics, no Latin, and Greek." Shocking! How happy we are to have a Stöcker, a Treitschke, and a Putkammer, who would not suffer a poison-plant like that to spring on German soil!

THE LEGAL POSITION OF MARRIED WOMEN.*

By Mrs. ANNA GARLIN SPENCER.

IT is my intention to indicate the historical scope and present bearings of my topic by a brief analysis of the following four conditions of social order involved in its consideration, viz.:

1. The law of social development underlying the various legal positions of married women, historically traced.

2. Classification of the principal types of marriage.

3. Summary of existing laws of married women in the United States.

4. Practical suggestions prompted by the study of these past and present facts.

Our first point (the social law controlling the varying position of married women) brings us at once to the fact that physical unions of men and women must have preceded all legal definitions of their relation to each other, or to their offspring. We begin to call these unions marriage, when the first headland of rude ceremonial selection appears above the sea of promiscuous passions. For a long while yet, no legal enactments fix the status of the wife; but from the time of

* A paper read before the Association for the Advancement of Women, at Boston, October 14, 1880.

the most rudimentary marriage, on to the highest types of sexual union, those social laws which are the seed of governmental codes, and without knowledge of which we can not understand those codes, deal with woman in her wedded state. We find the position of the married woman, as defined by these social laws, written and unwritten—and, if unwritten, quite as likely to be stringently enforced—to furnish examples of every grade of condition, from the captured or purchased slave to the comparatively equal partner. Moreover, we find the woman sometimes in possession of the most personal freedom in the lowest general social development. What law governs these widely diverging conditions?

The student of sociology must be convinced that the *evolution of the family determines, in its different stages, the differing position of the married woman.*

For proof of this statement we have only to consider the following facts: Progress from barbarism to civilization is marked by ever-increasing political control, as opposed to accidental, shifting despotisms of powerful individuals on the one side, and to purposeless anarchy of the masses on the other. "Political control rests primarily on distinct relationships of blood." For the structural cohesion of the family, established by this definite blood-relationship, alone makes possible the structural cohesion of many families in the organism we call society. The unity of the family, therefore, being the fundamental condition of the unity of society, it is secured beyond peradventure by successive changes which tend more and more to establish certainty of descent, of preservation, and of care of offspring. Probably every form of relation between man and woman, from promiscuity to pure monogamy, has been in existence at every stage of human development. But the *prevailing type* of sexual union has differed at each of these differing stages. How do we know which are the higher and which are the lower of these types? By the application of the simple test-question, which the more perfectly secures that organization of the family which is the primary necessity of the organization of the state?

In the building up of the state, the primitive need is sufficient power and permanency of control to make law supreme over the individual will. And where the personal wishes or rights, even of men, come in conflict with this initial step toward social order, those personal wishes and rights are ruthlessly sacrificed; not because individual liberty is ignored in the process of development, but rather because individual liberty can only be permanently secured by making it second to social order in sequence of evolution. On exactly the same principle, the building up of the family, which precedes the establishment of political order, must begin in the strong foundation-wall of family unity, even although to that unity must be sacrificed the individual rights of every member of the family except its acknowledged head. Hence we

discover the law which underlies the varieties and changes in the condition of married women to be a law which concerns itself first, not with the rights of any individual *inside* the family, but with the development and defense of the family itself. For this development and defense of the family the following conditions must necessarily be secured :

a. Certainty of parentage of offspring on both male and female side, that inheritance may be secured.

b. Protection of the family from external encroachments of war, conquest, etc.

c. Nourishment of offspring, and such protection of the mother as will secure that end.

d. Repression of sexual passion to certain recognized limits.

e. Preservation of the family against the disruptive tendencies of internal strife.

Bearing these general principles in mind, we turn to the next division of our subject, viz. :

The Classification of the Principal Types of Marriage.—If our previous positions are correct, we must rank marriage types, from lowest to highest, by their growing ability to fulfill these conditions, tabulated above, of the development and defense of the family order :

We find the first primitive marriage to be a simple announcement of intention to live together by a man and woman, ratified by some such rude ceremony as that of the "Navajos, who sit down on opposite sides of a basket made to hold water and filled with some kind of food, and partake of it. . . . This proceeding makes them husband and wife." This type of union offers perfect freedom of choice to both parties to the contract, and, being broken at pleasure, is repeated as many times and dissolved as often as caprice indicates. Hence it offers but slight protection to the offspring, and the society in which it is found the prevailing type of sexual union is among the lowest in grade of development.

The next step up in marriage conditions is that called polyandry, or the union of several husbands to one wife. It is not to be inferred from this definition that polyandry at first, or generally, restrains the sexual indulgence of men to the fractional marital rights indicated. Far from it. Polyandry simply lays the corner-stone of the family foundation-wall by making a local home—i. e., a place where children can be generally known to belong. Let us see how this is done. Nature makes certain the parentage of the child on the mother's side, as she does not on the father's. Hence the primitive necessity in building the family is to put the mother in a definite place, and cluster her children round her, whether you can know the paternity of those children or not. Descent of name and inheritance

are possible, then, on one side the line. Fatherhood may pass through many stages, from a light flitting from one polyandric household to another, on to that form in which the several husbands of the female head of such households must be distinctly related to each other, but, through all the varieties of polyandry, the fixed stake of classification and localization of offspring defines the family outline. This type of marriage affords sometimes to women, "as in Thibetan polyandry, freedom and equality of companionship with men." It everywhere gives her such measure of power as her physical strength can command; and by interesting many men, although ever so slightly, in the welfare of some one household, it offers the beginning of protection to offspring, in supplies of food and defense in war.

The next step up in marriage types is to what we call polygyny, or the union of several wives with one husband. This establishes the descent of the child on both male and female sides of the marriage union; but *it destroys every vestige of freedom and equality in the condition of the wife.* With polygyny begins the legal, recognized slavery of woman to man in the domestic relation. Remember, however, that nature is securing first the family order, and only after that is attained can look out for personal rights; and let us note, without prejudice, the advance of this type of marriage, in family structure, above polyandry. Descent, reckoned on the father's side, not only secures double ancestry, but, on account of the greater brute strength of men, is more likely to keep the inheritance intact. Again, although women enjoy a nominal freedom before this point, it is only that gained by personal qualities—it has no bulwark of law. Hence the average woman, physically weaker than man, is his prey. Polygyny places her person in the custody of her husband, and thus enlists for its defense, against lawless raids of masculine lust, the selfish instinct of preservation of one's own property. And this protection of woman is absolutely indispensable, under barbarous conditions, not only for the growth of chastity on her part, but for the nourishment of offspring. We have this great gain in the family order in this type, that the *father* is brought into the household, and placed beside the mother and children. But, in order to get him there, we have to bring in with him facilities for the indulgence of his passions *within* the home, equal, or nearly so, to those he has before enjoyed outside the home. Repression of sexual passion to certain recognized limits was one of the conditions of family order we noted above. Polygyny marks the point at which the *chastity* of the mother was made the limit on one side, and the indulgence of the father, *only inside the household*, the limit on the other. This was a great gain in the line of repression, even although it gave man absolute power over as many wives as he could secure.

The next step up in marriage development we may call *rudimentary monogamy.* The last essential of family unity we noted was

the preservation of the family against the disruptive tendencies of internal strife. Polygyny partially and externally secures this by placing the control of the family in the hands of a recognized head, and that head the member of the household indisputably the best able to hold his position against the other members. But the elements of discord and strife were left in the family, in the jealousies of the several wives, and in the conflicting claims of their children. When death removed the household despot, if not before, these elements of disintegration worked against the family structure. Rudimentary monogamy was the attempt to settle by law the relative positions of a man's several wives, placing one on a secure height above the others, to insure a certain descent of title, property, and power to her children. Roman law gives us the most perfect legal form of this transition stage toward pure monogamy. The Roman patrician was entitled by law to three wives, but he could only have *one of the highest kind*. This superior order of wife, whom the law protected against equal rivals, must be of the same high birth as the husband, could alone legitimatize his children to the extent of transmission of title and estate (save as he exercised his legal power of adoption) ; and the marriage ceremony, made binding by solemn religious rites, was annulled only by death. The second grade of wife could be of inferior birth, and was united to her noble husband merely by a civil service, which gave him full power over her, but which secured her legal protection and support, and could be annulled by divorce. The third grade of wifehood was one which gave perfect legal independence to the woman, and also removed from her all legal protection. Simple announcement of intention to assume such a relation was the only preliminary needed for this union ; it could be dissolved by mutual consent. Rudimentary monogamy, you observe, raised the standard of a life-long union of one man with one woman, to beget, bear, and rear one set of offspring. And the Roman law, though recognizing other unions as legal, pushed them away as far as possible from this germinal seed of perfect family unity. Thus the seed grew, and we come rapidly on the to the last type of marriage, viz. :

Pure monogamy. This form of sexual union recognizes no other as legally admissible. Indulgence of passion there may be outside this narrow bond of one man to one woman, but it is unlawful, and its fruits have no legal place in the social order of the family. This is the type dominant in our civilization, and we have seen how slowly it has been built up, and for what high ends of government.

The Legal Position of Married Women To-day in the United States.—Our laws are all founded on and modifications of the "common law" of England, which was in turn, for the most part, a gift from old Roman jurists to our civilization. This common law exemplifies in every word the emphasis formerly placed on the authority of recognized rulers, in general government and in domestic

order. The common law "merged the married woman's whole legal being in that of her husband." She might be heir to untold wealth; marriage made her husband legal owner of it all, with unchecked power over it, as well as over her expenses. She might be a Minerva of wisdom, but her every action must be obedient to her husband, though he were little above the idiot. She might be mother of a score of children, but her husband could will them all away from her control, even the unborn babe he should never behold. In short, she might be or do anything; her husband still had full power over her body, her actions, her property, her earnings, and her children. But, on the other hand, he was responsible for her crimes, her debts, her support, her protection from violence, and the support and protection of her children. If he could legally "correct her with a stick no bigger than his thumb," and that not with "cruelty," he must also answer by his own payment, or imprisonment, for her misdeeds, as for a minor child's. Thus was the monogamic unity of the family secured by the strong domestic control of a father-head, just as the organic unity of society was secured by the strong political control of an unlimited monarchy. And no doubt both forms of despotism have been necessary in the appropriate stages of human development. But, at the time our republic was born, it had become apparent to the dullest, as it had long been to prophetic minds, that the hour had arrived when political control must concern itself not only with its first great task, viz., the development of social order, but must set itself at work also on its second great effort, viz., *the definition and defense of personal rights inside of this social order.* Not only this, but it became apparent that the domestic order also contained within itself necessities for like definition and defense of personal rights. The tendency thus inaugurated naturally took shape first, in its relation to married women, in an increase of secured independence of personal action, and of parental control, to women cruelly abused or divorced or deserted by their husbands. It began to be seen that the wives of *bad* or *incompetent* men should not be the domestic slaves of those men. It began to be seen that the children of bad or incompetent fathers should have the protection and support he failed to give them provided by the other parent, who to that end should be endowed with certain powers of ownership of property and person. And, as legislators had their attention drawn to these truths by concrete illustrations of abuses, by husbands and fathers, of the law which gave them absolute power over wife and children, they tried to alter the law in one and another particular. Hence we find the old "common law," in the different States of our Union, with its darker spots torn out and patched over with new readings to such a degree that, in many cases, the original fabric is hardly distinguishable. A brief summary of these tearings out and patchings over will enable us to see the drift of legal changes respecting the matter in hand.

The common law recognized no legal right as inhering in the mar-

ried woman, *except the one supreme right of holding her husband true to the monogamic type of marriage.* The legal position of married women to-day represents as many different views of woman's legal rights in marriage as there are States in our Union. But all those States recognize that she has some rights of independent action, not only when her husband is bad or imbecile, but when he is good or competent. The confusing varieties of legislation on this point make summarizing extremely difficult. No generally received principle respecting the just legal relation between husband and wife has controlled the sweeping changes which the legislation of the last thirty years records. These changes have been simply irregular, fitful, and detached attempts to make the domestic yoke of women easier, in places where it was found specially to hurt. We find, however, that there is some approach to uniformity in the changes of the statute laws of old States, and that the legal codes of the new States take counsel generally of the old constitutions which have departed most widely from the original common-law slavery of women in the domestic relation.

Let us see what rights of independent action are now insured, or partially so, to married women.

We have thirty-eight States in our Union. In twenty-eight of these a married woman has legal ownership and separate control of all property owned by her before, or descending to her after, marriage. In ten States her property owned before marriage is secured against any attempt of her husband to alienate it without her consent, but he has full control of incomes resulting from it; and in two of these States the husband receives property which, were she single, would descend to her. In twenty-one States a married woman's earnings are her separate property; in eight States her right to such earnings is legally restricted in various ways, as in Georgia, where a married woman can own absolutely as separate property her own and her children's earnings deposited in a savings-bank "if the same do not exceed two thousand dollars"; and in nine States a woman can hold absolutely in her own control all property coming to her from any source save by gift of her husband—as in Massachusetts, where a recent decision of the Court under this law was that a woman could not own her own wardrobe if her husband gave her the money to buy it! This decision, we may add, a legislative enactment has very recently attempted to overrule by ordaining that a woman *may own* her personal apparel in Massachusetts.

In twenty-one States a married woman is solely liable for her antenuptial debts; in five States her husband is liable for them to the extent of the property she brought to the common stock at marriage.

In sixteen States a married woman can make a will devising her separate property according to her wish; in twelve States she can so will her estate, provided she gives her husband as much as the law of

that State would give him if she died intestate; and in one State she can make a will only by her husband's written consent.

In nine States special enactments qualify a married woman to be executrix or administratrix; in others the right is secured under other forms of law.

In twenty-four States a married woman may sue and be sued separately from her husband; in other States provision is made for their union in various specified suits.

In fourteen States married women can cause their husbands' lives to be insured for their benefit, and retain the policy against all outside claims, within certain limits of amount. In twenty-two States there are homestead acts which secure a certain amount of property, the home and its belongings, to the widow or wife, against all creditors of the husband. In fifteen States a married woman may carry on and control a separate business without limitations; in ten States she can do so with some restrictions, which vary from a simple requirement that she shall file her intention to do so in court to the necessity of proving that her husband does not support her properly.

In three States special enactments provide for trusteeships to guard the wife's interests against the husband's claims; in other States similar results may be attained by marriage contracts, and special provisions of various sorts. In seven States a woman is solely responsible for her personal debts. In three States a married woman is responsible for her husband's debts, and in two others is so responsible unless taking certain legal precautions at marriage. In six States her separate property is liable for family debts, although in most instances she is so liable only in the second degree, all the husband's property being jeopardized first.

In seven States the division of property on the death of either husband or wife, whether there be any issue or not, is very nearly or quite equal; in most of the other States the widower has nearly all the rights in the wife's estate he had under the common law, and she has a life interest in his real, and absolutely only a fraction of his personal, property.

In ten States, husbands and wives can make contracts with each other.

In regard to the rights of guardianship, the father is generally held first natural guardian of the children, and the mother second.

In Iowa, which, on the whole, seems to lead all the other States in giving equal marital and parental rights to husband and wife, the two parents are equal guardians of the children, neither having the power to remove them from the home without the consent of the other, and on the death of either parent the other is sole guardian. Moreover, in this State the wife can not be compelled by the husband to leave the home, against her wishes, to follow him in any wanderings. In Iowa, also, the family expenses are chargeable equally to both parents, and

on divorce the support of the children is still a mutual burden, and custody of the children is decreed to either parent—on discretion of the Court.

We come now to our last division, viz., practical considerations arising from the study of these facts of history, and of present condition.

I have tried to give the more important laws as they stand upon the statute-books. They mark an enormous increase of personal power in the married woman's condition during the last thirty years. But probably her actual legal position is more restricted still than these statutes would indicate. The average man wishes to do justice, as fast as he can see it. So the legislator responds to petitions to change laws deemed offensive. But the lawyer, accustomed to be guided by precedent, and fearful that decisions under the law of his State may be overruled by an appeal to a higher court, is shy of taking full advantage of a new statute. Thus it comes about that a woman must not place full reliance upon the "acts and resolves" of the General Assembly of her State. She must find out what is the actual practice among lawyers and judges. For instance, in Massachusetts, the law declares that woman owns her own property, and may manage it free from all interference; yet so many troublesome conditions are to be complied with, and in important cases there are so many possible risks from technical barriers, that many women still find it to their advantage to empower some man-friend with a trustee's external rights, that she may really control her own, through him in his capacity of agent. For instance, again, in California, where the "common property" of husband and wife is wholly under his control, and although her estate is called "separate," and she is declared to be legally protected in its control, the profits of both her and his separate estate are called "common property," and he has full disposal of them, unless by special arrangement otherwise. These, and many other instances, prove that the legal powers conferred on married women are often so *executed* and *interpreted* as to fall far short of their apparent scope. The first thing, therefore, for every married woman to do is to find out the statutes of her own State respecting her position, and then learn the actual practical bearing of the laws in any point that touches her. It may be that some movement for national legislation on the legal position of married women will be found necessary. Certainly, it ought not to be possible for men and women to assume the solemn obligation of marriage in one State, under one set of legal conditions, and one or the other party to the contract throw off those obligations in another State, under another set of legal conditions. There should be some uniformity of law, as to marriage contract and its dissolution by divorce, in the different States. Another practical consideration is this: women must be prepared to assume personal responsibilities as

they attain personal rights. No State Legislature has said "Go to, let us make the married woman the legal equal of her husband," but legislation has pointed in that direction more and more during these last years, so pregnant of changes in her position. If the married woman is to be the legal equal of her husband, she will find she must accept the penalties as well as gains of independence. The laws already indicate this. For instance, as soon as women were allowed to hold as separate property what they owned before marriage, they were made solely liable for their own antenuptial debts. As soon as women were allowed to hold as separate property what they gained in any way after marriage, they were made liable for their own separate debts incurred after marriage. And as soon as they were allowed to carry on separate trades and business, they were made partially or equally liable with the husband for the support of the family. Not that legislation in these two directions has been simultaneous or universally united; but these two tendencies are to be noted. And the one is the legitimate corollary of the other. As fast as the wife is removed from wardship to her husband, she should be required to assume her personal obligations and release him from them. The practical question now before us is, How far are these twin tendencies to proceed? Judging from facts of existing law, and analogies of other social movements, we may arrive at the conclusion that, just as in political control the overmastering impulse of growth is in the direction of the *greatest possible freedom of the individual, consistent with social cohesion*, so in domestic control the irresistible movement is in the direction of the most perfect *legal equality of the married partners, consistent with family unity*.

These exact limits we can not yet master in superficial detail, either in political government or family life. But past experience shows us that the measure of personal independence which woman can gain inside the family structure will alone be hers permanently. All attempts to abrogate the legal marriage tie, or to make her sole owner of the children, in order to secure her independent sovereignty, have been abortive movements, leading to a reversion to less developed forms of sexual union, or even to that promiscuity which (like political anarchy of revolt) demands the despotic rule of the strongest to lay again the foundations of progress. The States of our Union which have carried their legislative changes farthest in the direction of legal independence of married women have not yet settled fully the questions involved. For instance, in States accepting the principle of equal ownership of personal estate and equal responsibility for personal debts, the question as to which parent should be solely or chiefly responsible for the support of the family is only half met. In Connecticut (by its recent sweeping revision, which places it among the most advanced in respect to our topic) the father is made responsible, alone, for family expenses. But, if a woman owns personal property, should

she be allowed to shirk all family obligations, while presumably having a very considerable influence in determining the scale of living? Still more, should she be allowed to assist her husband in cheating his creditors, by contracting family debts in his name, which he can repudiate by passing his property into her hands, or by merely swearing he is bankrupt?

And, on the other hand, where, as in Iowa, the two heads of the married firm are made equally responsible by law for family expenses, should there not be an accompanying provision making the married partners equal owners of all *current incomes?*

And, again, where the principle of equality of rank of husband and wife, father and mother, in the home is fully conceded, how can it be applied in the detail of the unity of name and residence demanded? Man, as the senior partner, now gives the name and determines the legal residence. Some women claim the right to retain their own single names, and demand a legal recognition of that right. Should that be yielded in any case, which parent would then claim superiority of child-ownership in giving a name to the children? These and other delicate questions of adjustment must be determined, not by *a priori* reasoning, but by an appeal to past and present experience, with these two principles in view, viz., the primary need of family unity as a condition of social order, and the secondary need of increasing measure of personal independence for women within that unity. And since our legislative changes have been, for the most part, attempts to limit the *power of abuse* of the domestic control vested in the man, rather than efforts to secure the freedom of women from that control by the husband, the result is an inconsistent medley of laws, which at one time recognize the married woman as an independent unit, and at another time as the mere ward of her husband. The great practical need for the parties most interested—thoughtful, intelligent women—is a clear ideal of the just legal relations of men and women. With that ideal in mind, the laws, and *especially the actual practice under those laws,* should be examined, and, where they come short, they may in time be amended by slow, pacific, but persistent methods of educational appeal.

A great help to this end is the work which contributed so much toward the changes in Connecticut laws, the work recently so ably done for Massachusetts by Messrs. Almy and Fuller, viz., the compilation by reliable lawyers of the present laws, with an indication of all inequalities, and the injustice resulting from them.

Meanwhile, as the band of ancient law, which made woman the domestic slave of man, protected her from a worse fate, and made possible the primitive home, so the inconsistencies of our present laws make that band flexible in adjustment, even by ignorant or unconscious workers, to the present and future needs of woman and the home. Protected by these ever-changing codes, the higher uses of

the family life will develop—the more internal unity of the married twain and the more perfect moral nourishment of their offspring will bring on a civilization which must write itself out in "sweeter manners, purer laws."

ROCK-WEATHERING, AS ILLUSTRATED IN CHURCH-YARDS.*

By Professor ARCHIBALD GEIKIE, F. R. S.

COMPARATIVELY little has yet been done in the way of precise measurement of the rate at which the exposed surfaces of different kinds of rock are removed in the processes of weathering. A few years ago some experiments were instituted by Professor Pfaff, of Erlangen, to obtain more definite information on this subject. He exposed to ordinary atmospheric influences carefully measured and weighed pieces of Solenhofen limestone, syenite, granite (both rough and polished), and bone. At the end of three years he found that the loss from the limestone was equivalent to the removal of a uniform layer 0·04 millimetre in thickness from its general surface. The stone had become quite dull and earthy, while on parts of its surface fine cracks and incipient exfoliation had appeared.† The time during which the observations were continued is, however, too brief to allow any general deductions to be drawn from them as to the real average rate of disintegration. Professor Pfaff relates that during the period a severe hailstorm broke one of the plates of stone. An exceptionally powerful cause of this nature might make the loss during a short interval considerably greater than the true average of a longer period.

It occurred to me recently that data of at least a provisional value might be obtained from an examination of tombstones freely exposed to the air in graveyards in cases where their dates remained still legible or might be otherwise ascertained. I have accordingly paid attention to the older burial-grounds in Edinburgh, and have gathered together some facts which have, perhaps, sufficient interest and novelty to be communicated to the Society.

At the outset it is of course obvious that, in seeking for data bearing on the general question of rock-weathering, we must admit the kind and amount of such weathering, visible in a town, to be in some measure different from what is normal in nature. So far as the disintegration of rock-surfaces is effected by mineral acids, for example, there must be a good deal more of such chemical change where sulphuric acid is copiously evolved into the atmosphere from thousands of chimneys, than in the pure air of country districts. In these

* A paper read to the Royal Society of Edinburgh, on April 19, 1880.

† "Allgemeine Geologie als exacte Wissenschaft," p. 317.

respects we may regard the disintegration in towns as an exaggeration of the normal rate. Still, the difference between town and country may be less than might be supposed. Surfaces of stone are apt to get begrimed with dust and smoke, and the crust of organic and inorganic matter deposited upon them may in no small measure protect them from the greater chemical activity of the more acid town rain. In regard to the effect of daily or seasonal changes of temperature, on the other hand, any difference between town and country may not impossibly be on the side of the town. Owing, probably, to the influence of smoke in retarding radiation, thermometers placed in open spaces in town commonly mark an extreme nocturnal temperature not quite so low as those similarly placed in the suburbs, while they show a maximum day temperature not quite so high.

The illustrations of rock-weathering presented by city graveyards are necessarily limited to the few kinds of rock employed for monumental purposes. In this district the materials used are of three kinds: 1. Calcareous, including marbles and limestones; 2. Sandstones and flagstones; 3. Granites.

I. Calcareous.—With extremely rare exceptions, the calcareous tombstones in our graveyards are constructed of ordinary white saccharoid Italian marble. I have also observed a pink Italian shell-marble and a finely fossiliferous limestone containing fragments of shells, foraminifera, etc.

In a few cases the white marble has been employed by itself as a monolith in the shape of an obelisk, urn, or other device; but most commonly it occurs in slabs which have been tightly fixed in a framework of sandstone. These slabs, from less than one to fully two inches thick, are generally placed vertically; in one or two examples they have been inserted in large horizontal sandstone slabs or "through-stanes." The form into which it has been cut and the position in which it has been erected have had considerable influence on the weathering of the stone.

A specimen of the common white marble employed for monumental purposes was obtained from one of the marble works of the city, and examined microscopically. It presented the well-known granular character of true saccharoid marble, consisting of rounded granules of clear, transparent calcite, averaging about $\frac{1}{100}$ inch in diameter. Each granule has it own system of twin lamellations, and not unfrequently gives interference colors. The fundamental rhombohedral cleavage is everywhere well developed. Not a trace exists of any amorphous granular matrix or base holding the crystalline grains together. These seem molded into each other, but have evidently no extraordinary cohesion. A small fragment placed in dilute acid was entirely dissolved. There can be no doubt that this marble must be very nearly pure carbonate of lime.

The process of weathering in the case of this white marble pre-

sents three phases, sometimes to be observed on the same slab, viz., superficial solution, internal disintegration, and curvature with fracture.

1. *Superficial solution* is effected by the carbonic acid and partly by the sulphuric acid of town rain. When the marble is first erected it possesses a well-polished surface capable of affording a distinct reflection of objects placed in front of it. Exposure for not more than a year or two to our prevalent westerly rains suffices to remove this polish, and to give the surface a rough, granular character. The granules which have been cut across or bruised in the cutting and polishing process are first attacked, and removed in solution or drop out of the stone. An obelisk in Greyfriars Churchyard, erected in memory of a lady who died in 1864, has so rough and granular a surface that it might readily be taken for a sandstone. So loosely are the grains held together that a slight motion of the finger will rub them off. In the course of solution and removal, the internal structure of the marble begins to reveal itself. Its harder nests and veinings of calcite and other minerals project above the surrounding surface, and may be traced as prominent ribs and excrescences running across the faint or illegible inscriptions. On the other hand, some portions of the marble are more rapidly removed than others. Irregular channels, dependent partly on the direction given to trickling rain by the form of the monumental carving, but chiefly on original differences in the internal structure of the stone, are gradually hollowed out. In this way the former artificial surface of the marble disappears, and is changed into one that rather recalls the bare, bleached rocks of some mountain-side.

The rate at which this transformation takes place seems to depend primarily on the extent to which the marble is exposed to rain. Slabs which have been placed facing to the northeast, and with a sufficiently projecting architrave to keep off much of the rainfall, retain their inscriptions legible for a century or longer. But even in these cases the progress of internal disintegration is distinctly visible. Where the marble has been less screened from rain, the rapidity of waste has been sometimes very marked. A good illustration is supplied by the tablet of G—— G——, on the south side of Greyfriars Churchyard, who died in 1785.* This monument had become so far decayed as to require restoration in 1803. It is now, and has been for some years, for the most part utterly illegible. The marble has been dissolved away over the center of the slab to a depth of about a quarter of an inch. Yet this monument is by no means in an exposed situation. It faces eastward in a rather sheltered corner, where, however, the wind eddies in such a way as to throw the rain against the part of the stone which has been most corroded.

* For obvious reasons I withhold the names carved on the tombstones referred to in this communication.

In the majority of cases superficial solution has been retarded by the formation of a peculiar gray or begrimed crust, to be immediately described. The marble employed here for monumental slabs appears to be peculiarly liable to the development of this crust. Another kind of white marble, sometimes employed for sculptured ornaments on tombstones, dissolves without crust. It is snowy white, and more translucent than the ordinary marble. So far as the few weathered specimens I have seen enable me to judge, it appears to be either Carrara marble or one of the strongly saccharoid, somewhat translucent varieties employed instead of it. This stone, however, though it forms no crust, suffers marked superficial solution. But it escapes the internal disintegration which, so far as I have observed, is always an accompaniment of the crust. But the few examples of it I have met with hardly suffice for any comparison between the varieties.

2. *Internal Disintegration.*—Many of the marble monuments in our older churchyards are covered with a dirty crust, beneath which the stone is found on examination to be merely a loose, crumbling sand. This crust seems to form chiefly where superficial solution is feeble. It may be observed to crack into a polygonal network, the individual polygons occasionally curling up so as to reveal the yellowish-white crumbling material underneath. It also rises in blisters, which, when they break, expose the interior to rapid disintegration.

So long as this begrimed film lasts unbroken the smooth face of the marble slab remains with apparently little modification. The inscription may be perfectly legible; the moment the crust is broken up, however, the decay of the stone is rapid. For we then see that the cohesion of the individual crystalline granules of the marble has already been destroyed, and that the merest touch causes them to crumble into a loose sand.

It appears, therefore, that two changes take place in upright marble slabs freely exposed to rain in our burial-grounds—a superficial, more or less firm crust is formed, and the cohesion of the particles beneath is destroyed.

The crust varies in color from a dirty gray to a deep brown-black, and in thickness from that of writing-paper up to sometimes at least a millimetre. One of the most characteristic examples of it was obtained from an utterly decayed tomb (erected in the year 1792), on the east side of Canongate Churchyard. No one would suppose that the pieces of flat dark stone lying there on the sandstone plinth were once portions of white marble. Yet a mere touch suffices to break the black crust, and the stone at once crumbles to powder. Nevertheless, the two opposite faces of the original polished slab have been preserved, and I even found the sharply-chiseled socket-hole of one of the retaining nails. The specimen was carefully removed and soaked in a solution of gum, so as to preserve it from disintegration. On submitting the crust of the marble to microscopic investigation, I found it to consist

of particles of coal, grains of quartz-sand, angular pieces of broken glass, fragments of red brick or tile, and organic fibers. This miscellaneous collection of town dust was held together by some amorphous cement which was not dissolved by hydrochloric acid. At my request my friend Mr. B. N. Peach tested it with soda on charcoal, and at once obtained a strong sulphur reaction. There can be little doubt that it is mainly sulphate of lime. The crust which forms upon our marble tombstones is thus a product of the reaction of the sulphuric acid of the town rain upon the carbonate of lime. A pellicle of amorphous gypsum is deposited upon the marble and incloses the particles of dust which give the characteristic sooty aspect to the stone. This pellicle, of course, when once formed, is comparatively little affected by the chemical activity of rain-water. Hence the conservation of the even surface of the marble. It is liable, however, to be cracked by an internal expansion of the stone to which I shall immediately refer, and also to rise in small blisters, and, as I have said, its rupture leads at once to the rapid disintegration of the monument.

The cause of this disintegration is the next point for consideration. Chemical examination revealed the presence of a slight amount of sulphate in the heart of the crumbling marble ; but the quantity appeared to me to be too small seriously to affect the cohesion of the stone. I submitted to microscopic examination a portion of a crumbling urn of white marble in Canongate Churchyard. The tomb bears a perfectly fresh date of "1792" cut in sandstone over the top ; but the marble portions are crumbling into sand, though the structure faces the east, and is protected from vertical rain by arching mason-work. A small portion of the marble retaining its crust was boiled in Canada balsam, and was then sliced at right angles to its original polished surface. By this means a section of the crumbled marble was obtained which could be compared with one of the perfectly fresh stone. From the dark outer amorphous crust with the carbonaceous and other miscellaneous particles, fine rifts could be seen passing down between the separated calcite granules, which in many cases were quite isolated. The black crust descends into these rifts, and likewise passes along the cleavage-planes of the granules. Toward the outer surface of the stone, immediately beneath the crust, the fissures are chiefly filled with a yellowish, structureless substance, which gave a feeble glimmering reaction with polarized light, and inclosed minute amorphous aggregates like portions of the crust. It probably consists chiefly of sulphate of lime. But the most remarkable feature in the slide was the way in which the calcite granules had been corroded. Seen with reflected light, they resembled those surfaces of spar which have been placed in weak hydrochloric acid to lay bare inclosed crystals and zeolites. The solution had taken place partly along the outer surfaces, so as to produce the fine passages or rifts, and partly along the cleavage. Deep cavities, defined by intersecting cleavage-planes, appeared

to descend into the heart of some of the granules. In no case did I observe any white pellicle such as might indicate a redeposit of lime from the dissolved carbonate. Except for the veining of probable sulphate just referred to, the lime when once dissolved had apparently been wholly removed in solution. There was further to be observed a certain dirtiness, so to speak, which at the first glance distinguished the section of crumbled marble from the fresh stone. This was due partly to corrosion, but chiefly to the introduction of particles of soot and dust, which could be traced among the interstices and cleavage lamellæ of the crystalline granules, for some distance back from the crust.

It may be inferred, therefore, that the disintegration of the marble is mainly due to the action of carbonic acid in the permeating rain-water, whereby the component crystalline granules of the stone are partially dissolved and their mutual adhesion is destroyed. This process goes on in all exposures, and with every variety in the thickness of the outer crust. It is distinctly traceable in tombstones that have not been erected for more than twenty years. In those which have been standing for a century it is, save in exceptionally sheltered positions, so far advanced that a very slight pressure suffices to crumble the stone into powder. But with this internal disintegration we have to take into consideration the third phase of weathering to which I have alluded. In the upright marble slabs it is the union of the two kinds of decay which leads to so rapid an effacement of the monuments.

3. *Curvature and Fracture.*—This most remarkable phase of rock-weathering is only to be observed in the slabs of marble which have been firmly inserted into a solid framework of sandstone and placed in an erect or horizontal position. It consists in the bulging out of the marble, accompanied with a series of fractures. The change can not be explained as mere sagging by gravitation, for it usually appears as a swelling up of the center of the slab, which continues until the large, blister-like expansion is disrupted. Nor is it by any means exceptional; it occurs as a rule on all the older upright marble tablets, and is only found to be wanting in those cases where the marble has evidently not been fitted tightly into its sandstone frame. Wherever there has been little or no room for expansion, protuberance of the marble may be observed. Successive stages may be seen, from the first gentle uprise to an unsightly swelling of the whole stone. This change is accompanied by fracture of the marble. The rents in some cases proceed from the margin inward, more particularly from the upper and under edges of the stone, pointing unmistakably to an increase in volume as the cause of fracture. In other cases the rents appear in the central part of the swelling, where the tension from curvature has been greatest.

Some exceedingly interesting examples of this singular process of

weathering are to be seen in Greyfriars Churchyard. On the south wall, in the inclosure of a well-known county family, there is an oblong upright marble slab measuring $30\frac{1}{4}$ inches in height by $22\frac{3}{8}$ inches in breadth, and three fourths of an inch in thickness, facing west. The last inscription on it bears the date 1838, at which time it was no doubt still smooth and upright. Since then, however, it has escaped from its fastenings on either side, though still held firmly at the top and bottom. It consequently projects from the wall like a well-filled sail. The axis of curvature is of course parallel to the upper and lower margins, and the amount of curvature from the original vertical line is fully two and a half inches, so that the hand and arm can be inserted between the curved marble and the perfectly vertical and undisturbed wall to which it was fixed. At the lower end of this slab a minor curvature, to the extent of one eighth of an inch, is observable coincident with the longer axes of the stone. In both cases the direction of the bending has been determined by the position of the inclosing solid frame of sandstone which resisted the internal expansion of the marble. Freed from its fastenings at either side, the stone has assumed a simple wave-like curve. But the tension has become so great that a series of rents has appeared along the crest of the fold. One of these has a breadth of one tenth of an inch at its opening.* Not only has the slab been ruptured, but its crust has likewise yielded to the strain, and has broken up into a network of cracks, and some of the isolated portions are beginning to curl up at the edges, exposing the crumbling, decayed marble below. I should add that such has been the expansive force of the marble that the part of the sandstone block in the upper part of the frame exposed to the direct pressure has begun to exfoliate, though elsewhere the stone is quite sound.

More advanced stages of curvature and fracture may be noticed on many other tombstones in the same burying-place. One of the most conspicuous of these has a peculiar interest from the fact that it occurs on the tablet erected to the memory of one of the most illustrious dead whose dust lies within the precincts of the Greyfriars—the great Joseph Black. He died in 1799. In the center of the sumptuous tomb raised over his grave is inserted a large upright slab of white marble, which, facing south, is protected from the weather partly by heavy overhanging masonry, and partly by a high stone wall immediately to the west. On this slab a Latin inscription records with pious reverence the genius and achievements of the discoverer of carbonic acid and latent heat, and adds that his friends wished to mark his resting-place by the marble while it should last. Less than eighty years, however, have sufficed to render the inscription already partly illegible. The stone, still firmly held all round its margin, has bulged out

* It is a further curious fact that the slab measures half an inch more in breadth across the center, where it has had room to expand, than at the top, where it has been tightly jammed between the sandstone slabs.

considerably in the center, and on the blister-like expansion has been rent by numerous cracks which run on the whole in the direction of the length of the stone.

A further stage of decay is exhibited by a remarkable tomb on the west wall of the Greyfriars Churchyard. The marble slab, bearing a now almost wholly effaced inscription, on which the date 1779 can be seen, is still held tightly within its inclosing frame of sandstone slabs, which are firmly built into the wall. But it has swollen out into a ghastly protuberance in the center, and is, moreover, seamed with rents which strike inward from the margins. In this and in some other examples the marble seems to have undergone most change on the top of the swelling, partly from the system of fine fissures by which it is broken up, and partly from more direct and effective access of rain. Eventually the cohesion of the stone at that part is destroyed, and the crumbling marble falls out, leaving a hole in the middle of the slab. When this takes place disintegration proceeds rapidly. Three years ago I sketched a tomb in this stage on the east wall of Canongate Churchyard. In a recent visit to the place I found that the whole of the marble had since fallen out.

The first cause that naturally suggests itself, in explanation of this remarkable change in the structure of a substance usually regarded as so inelastic, is the action of frost. White statuary marble is naturally porous. It is rendered still more so by that internal solution which I have described. The marble tombstones in our graveyards are, therefore, capable of imbibing a relatively large amount of moisture. When this interstitial water is frozen, its expansive force as it passes into the solid state must increase the isolation of the granules and augment the dimensions of a marble block. I am inclined to believe that this must be the principal cause of the change. Whatever may be the nature of the process, it is evidently one which acts from within the marble itself. Microscopic examination fails to discover any chemical transformation which would account for the expansion. Dr. Angus Smith has pointed out that in towns the mortar of walls may be observed to swell up and lose cohesion from a conversion of its lime into the condition of sulphate. I have already mentioned that sulphate does exist within the substance of the marble, but that its quantity so far as I have observed is too small to be taken into account in this question. The expansive power is exerted in such a way as not sensibly to affect the internal structure and composition of the stone, and this, I imagine, is most probably the work of frost.

The results of my observations among our burial-grounds show that, save in exceptionally sheltered situations, slabs of marble exposed to the weather in such a climate and atmosphere as those of Edinburgh are entirely destroyed in less than a century. When this destruction takes place by simple comparatively rapid superficial solution and removal of the stone, the rate of lowering of the surface amounts sometimes to

about a third of an inch (or roughly nine millimetres) in a century. Where it is effected by internal displacement, a curvature of two and a half inches with abundant rents, a partial effacement of the inscription and a reduction of the marble to a pulverulent condition may be produced in about forty years, and a total disruption and effacement of the stone within one hundred. It is evident that white marble is here utterly unsuited for out-of-door use, and that its employment for really fine works of art which are meant to stand in the open air in such a climate ought to be strenuously resisted. Of course, I am now referring not to the durability of marble generally, but to its behavior in a large town with a moist climate and plenty of coal-smoke.

II. Sandstones and Flagstones.—These, being the common building materials of the country, are of most frequent occurrence as monumental stones. When properly selected, they are remarkably durable. By far the best varieties are those which consist of a nearly pure fine silicious sand, with little or no iron or lime, and without trace of bedding structure. Some of our sandstones contain 98 per cent. of silica. A good illustration of their power of resisting the weather is supplied by Alexander Henderson's tomb in Greyfriars Churchyard. He died in 1646, and a few years afterward the present tombstone, in the form of a solid square block of freestone, was erected at his grave. It was ordered to be defaced in 1662 by command of the Scottish Parliament, but after 1688 it was repaired. Certain bullet-marks upon the stone are pointed out as those of the soldiery sent to execute the order. Be this as it may, the original chisel-marks on the polished surface of the stone are still perfectly distinct, and the incised lettering remains quite sharp. Two hundred years have effected hardly any change upon the stone, save that on the west and south sides, which are those most exposed to wind and rain, the surface is somewhat roughened, and an internal fine parallel jointing begins to show itself.

Three obvious causes of decay in arenaceous rocks may be traced among our monuments. In the first place, the presence of a soluble or easily removable matrix in which the sand-grains are imbedded. The most common kinds of matrix are clay, carbonates of lime and iron, and the anhydrous and hydrous peroxides of iron. The presence of the iron reveals itself by its yellow, brown, or red color. So rapid is disintegration from this cause, that the sharply-incised date of a monument erected in Greyfriars Church to an officer who died only in 1863 is no longer legible. At least one eighth of an inch of surface has here been removed from a portion of the slab in sixteen years, or at the rate of about three fourths of an inch in a century.

In the second place, where a sandstone is marked by distinct laminæ of stratification, it is nearly certain to split up along these lines under the action of the weather if the surface of the bedding planes is directly exposed. This is well known to builders, who are quite aware of the importance of "laying a stone on its bed." Examples may be observed

in our churchyards, where sandstones of this character have been used for pilasters and ornamental work, and where the stone set on its edge has peeled off in successive layers. In flagstones, which are merely thinly-bedded sandstones, this minuter lamination is fatal to durability. These stones, from the large size in which slabs of them can be obtained and from the ease with which they can be worked, form a tempting material for monumental inscriptions. The melancholy result of trusting to their permanence is strikingly shown by a tombstone at the end of the South Burying Ground in Greyfriars Churchyard. The date inscribed on it is 1841, and the lettering that remains is as sharp as if cut only recently. The stone weathers very little by surface disintegration. It is a laminated flagstone set on edge, and large portions have scaled off, leaving a rough, raw surface where the inscription once ran. In this instance a thickness of about one third of an inch has been removed in forty years.

In the third place, where a sandstone contains concretionary masses of different composition or texture from the main portion of the stone, these are apt to weather at a different rate. Sometimes they resist destruction better than the surrounding sandstone, so as to be left as prominent excrescences. More commonly they present less resistance, and are therefore hollowed out into irregular and often exceedingly fantastic shapes. Examples of this kind of weathering abound in our neighborhood. Perhaps the most curious to which a date can be assigned are to be found in the two sandstone pillars which until recently flanked the tomb of Principal Carstares in Greyfriars Churchyard. They were erected some time after the year 1715. Each of them is formed of a single block of stone about eight feet long. Exposure to the air for about one hundred and fifty years has allowed the original differences of texture or composition to make their influence apparent. Each is hollowed out for almost its entire length on the exposed side into a trough four to six inches deep and six to eight inches broad. As they lean against the wall beneath the new pillars which have supplanted them, they suggest some rude form of canoe rather than portions of a sepulchral monument.

Where concretions are of a pyritous kind, their decomposition gives rise to sulphuric acid, some of which combines with the iron and gives rise to dark stains upon the corroded surface of the stone. Some of the sandstones of this district, full of such impurities, ought never to be employed for architectural purposes. Every block of stone in which they occur should be unhesitatingly condemned. Want of attention to this obvious rule has led to the unsightly disfigurement of public buildings.

III. Granites.—In Professor Pfaff's experiments, to which I have already referred, he employed plates of syenite and granite, both rough and polished. He found that they had all lost slightly in weight at the end of a year. The annual rate of loss was estimated by him as equal

to 0·0076 millimetre from the unpolished and 0·0085 from the polished granite. That a polished surface of granite should weather more rapidly than a rough one is perhaps hardly what might have been expected. The same observer remarks that, though the polished surface of syenite was still bright at the end of not more than three years, it was less so than at first, and in particular that some figures indicating the date, which he had written on it with a diamond, had become entirely effaced. Granite has been employed for too short a time as a monumental stone in our cemeteries to afford any ready means of measuring even approximately its rate of weathering. Traces of decay in some of its feldspar-crystals may be detected, yet in no case that I have seen is the decay of a polished granite surface sensibly apparent after exposure for fifteen or twenty years. That the polish will disappear, and the surface will gradually roughen as the individual component crystals are more or less easily attacked by the weather, is of course sufficiently evident. Even the most durable granite will probably be far surpassed in permanence by the best of our silicious sandstones. But as yet the data do not exist for making any satisfactory comparison between them.—*Nature.*

THE STATE AS AN EDUCATOR.*

By H. H. WILSON.

OF all the institutions which we are proud to call American, none makes so great an expenditure as our system of public education, and none receives so little critical attention from those by whom it is supported. It is seldom referred to except for purposes of flattery. Of all the offspring of American liberty this is the pet, and, as usual, it is the spoiled child. And this will probably remain so as long as indiscriminate praise is more welcome than just criticism.

I purpose, in the few minutes allotted to me, to discover, if possible, the true sphere of the state in reference to the education of the young. I shall use the word *state* in its broadest sense—a community of persons living within a limited territory and bound together by political ties. If such a community has a right to exist, then it has a right to do anything that is necessary to maintain that existence—to appropriate private property and even to take life itself. But, while the power of the state is thus broad, its duty is proportionally narrow, namely, to protect the person and property of the subject from the violence and fraud of his fellows. While for this purpose no sacrifice is too great, yet to exact from the subject more than is necessary for this purpose is legalized spoliation; for, when you take of a man's property more

* Read before the State Teachers' Association at Seward, Nebraska, April 1, 1880.

than is necessary to protect his person and the remainder of his property, you violate those very rights for the protection of which alone governments are instituted among men. Then, before the state can be justified in undertaking any enterprise, it must be shown, first, that the thing to be done is necessary either for the maintenance of its own existence or for the protection of the persons and property of its subjects; and, second, it must also be shown that it can be done better by the state than by individual effort.

There is at present in America a strong tendency to enlarge this sphere of government. Indeed, it may be said that it is our national weakness to look to the Government for everything. Thousands seek to throw upon the state the responsibility for miseries brought on by their own injudicious actions. The fact is that, beyond the safety of person and property, government forms one of the least factors in that complex product called happiness. Our greatest danger is the danger of being governed too much. As a result of this tendency to increase the domain of government, we have technical and professional colleges established and maintained by the state. When tried by our first criterion, I apprehend that it would be difficult to show that it is necessary to educate physicians and lawyers at public expense in order to protect persons and property; and it may well be doubted whether the rapid increase in the membership of these professions, due in no small degree to these institutions, is a national blessing. "But," it is asked, "are not the physician, the advocate, the engineer, necessary to the convenience and happiness of the community?" Certainly, so are food, clothing and shelter; yet not even Bentham thought of providing these at public expense. Then what special claims can these institutions have upon the public? The same arguments that would justify the state in educating the lawyer and doctor would also justify it in endowing the grocer and clothier, for they, too, are necessary to the convenience and happiness of society.

Moreover, the state, by supporting these institutions of special education, inflicts a positive injury upon society in crowding these favored professions, by thus interfering with those laws of social equilibrium which alone should govern the choice of vocation. Whenever the state by special legislation renders one vocation more accessible than another, it injures society by turning into one channel the intellectual energy that rightfully belongs in another. If, then, our premise be correct, these expensive institutions of technical learning are beyond the true province of the state.

But if the state is not denied all right to teach, what instruction shall she give? I answer, those things that will enable the rising generation to perform intelligently their functions as citizens. Yet how many leave our state institutions learned in the literature of Greece and Rome, but ignorant of our own history; conversant with the ideal republic of Plato, but unacquainted with the writings of our own Hamilton;

charmed with the beauties of Homer and Virgil, but deficient in the elements of political economy; able to compute the distance of the sun, but incapable of explaining our system of national currency! Take, if you will, the curricula of the high schools, colleges, and universities of the land, and compute the percentage of studies found there that are calculated to make competent members of the commonwealth! And yet this is the boasted system of education upon which we are told the perpetuity of our government depends!

It now becomes necessary to apply to education our second test, namely: Can it be done more efficiently by the state than by individual effort? Many, no doubt, who are ready to accept the conclusions already reached on the subject of special education, will still be inclined to think that general instruction should be at the expense and under the control of the state. But, before we attempt to decide by what agency we can best attain a certain object, it is necessary that we should have a well-defined idea of that object. What, then, is the true object of education? It is, if I mistake not, to aid Nature in perfecting the individual. Its aim should be to promote, not to destroy, individuality. Its object is human development, but, in the language of Von Humboldt, it is human development in its richest diversity.

The great poet Goethe saw and the naturalist Von Baer formulated the truth that in all organic life development consists of a change from a state of homogeneity to a state of heterogeneity; that, as we ascend the scale of animal life, there is a gradual transition from the like to the unlike, from unity to diversity. The social organism is no exception to this general law, and so we find among savages a marked similarity in costume, food, habits of life and in opinions. But as we ascend the scale of civilization we find fewer universal habits and still fewer universal opinions. Indeed, it has been shown that those opinions which are universal usually date back to the childhood of the race, and hence are usually false. Then social as well as physical development is a change from the homogeneous to the heterogeneous. But all history shows that nations as well as individuals have not only a period of youth and of manhood, but also a period of decay and of death. What is the cause of this fatal event which nations like individuals have sought, but sought in vain, to evade? Where does this retrograde movement begin? Nations decline because the conditions of their development are reversed; and decay begins just at that point at which the tendency to heterogeneity is exchanged for the tendency to homogeneity—at that point at which the people cease to become more diversified and begin to become more and more alike. There is in the development of nations a unanimity of savagery, a diversity of progress, and again a unanimity of stagnation. In view of these facts it becomes the duty of the educator to give full scope to the individual, and to encourage rather than restrain the peculiarities of the young.

If these propositions be true, it is, then, by no means clear that the

state is the most efficient educator of youth. The vastness of the enterprise demands the most rigorous system. But the more rigorous the system the less room will there be for the development of individual differences. The tendency of such a system is to make the mind a mere receptacle which receives its daily portion of mental pabulum. Even if trained to think at all, they must of necessity be trained to think very much alike, which is but little better than no thought. In other words, as the system grows stronger the individual grows proportionally weaker.

China, whose philosophers first recognized the supremacy of force, and whose moralists gave us a code which, after twenty-five centuries have elapsed, is yet too exalted for practical life, was reduced to her present condition, not for want of talent, of which she had much, but by a most rigorous system of state education, which consisted, not of investigating new phenomena, but of conning by rote what their ancestors had taught them. But we need not go to the Orient to witness the effects of state education. Germany has a most unyielding system, whose fruits are already beginning to ripen. This gigantic system, the pride of the Old World and the wonder of the New, is fast reducing the German mind to a mere repository of facts and figures. It will be remembered that no one can enter a German university until he has spent nine years in the gymnasium, chiefly upon Latin and Greek. To show the influence of such a course of study, I can do no better than to quote the words of Lord Macaulay, who says: "Unfortunately, those grammatical and philological studies, without which it was impossible to understand the great works of Athenian and Roman genius, have a tendency to contract the views and deaden the sensibilities of those who follow them with extreme assiduity. A powerful mind which has been long employed in such studies may be compared to the gigantic spirit in the Arabian tale, who was persuaded to contract himself to small dimensions in order to enter within the enchanted vessel, and, when his prison had been closed upon him, found himself unable to escape from the narrow boundaries to the measure of which he had reduced himself."

France until recently had a most perfect system of state instruction. No private schools could be established without a license from the Minister of Education, and these might be closed at any moment by a simple order from that officer. Under this system France made rapid strides toward that condition in which China has so long remained. M. de Tocqueville, that clear-headed Frenchman to whom America owes so much, remarked that his countrymen of his day were much more alike than their ancestors even of the next previous generation.

There are reasons why the effects of state education will not so readily discover themselves in America. In the first place, our system is yet very imperfect. But the chief reason is our extensive foreign

immigration, whose heterogeneity tends to counteract the unifying influence of our education. This, however, can not always last, and we shall hope in vain if we hope to escape the effects of those influences which are shaping the destinies of other nations. True, we permit parents to educate their own children, but at the same time we tax them to support the education of all; and we shall find but few who are able and still fewer who are willing to pay others to educate their children and then do it themselves. So our system is virtually a prohibition upon all private schools.

Nor has America entirely escaped the dwarfing influence of such a system. A recent writer says that while the percentage of college graduates is rapidly increasing, strange as it may seem, the percentage of college-bred men in public positions is decreasing. This, however, does not show that we as Americans are slow to recognize ability, for in no other country is true merit so sure to be rewarded; but I believe it does show that our education has a tendency to unfit men for the practical affairs of life. The demand is not for cultured minds filled with facts tumbling over each other in the dark, but for minds trained to independent thought. The question is repeated more and more emphatically, not what do you know, but what can you do? Every vocation of life is crying itself hoarse for men—men with the intellectual audacity to think and the moral courage to do.

It is the tendency of state education to make all intellectually alike, by urging the slow and restraining the fast, by giving a surface polish to the dull and bedimming the brilliant. Its tendency is to crush genius and enthrone mediocrity. It is the great leveling influence of modern times. This procrustean system binds its tender victims upon its inexorable bedstead of iron, and if found too short it cruelly attempts to stretch them out, until not unfrequently the brittle thread of life itself is broken in the effort; and if, when placed upon it, they perchance extend beyond its limits, they are as remorselessly trimmed down to the required standard.

Fortunately for mankind, some of the great minds of the age escaped the influence of popular education. When at the age of fourteen Henry Thomas Buckle won his first prize, his parents asked him to name anything he chose as an additional reward, and, with his wonderful precocity, he asked to be removed from public school. His request was granted, and who that has read his "History of Civilization" can doubt the wisdom of his choice? Herbert Spencer, any one of whose numerous volumes would place him in the first rank, not only as a student of human nature but also as a philosopher and man of letters, was never at public school. John Stuart Mill, than whom England has never produced a greater, who united in one mind the wisdom of the ancients and the learning of the moderns, who was at once an Aristotle and a Bacon, who was not only a profound philosopher but also a practical man of affairs, was singularly exempt from the influ-

ence of public instruction. Should the glaciers once more descend from the north and sweep before them all that makes us a great people, leaving no vestige of civilization behind, would America be known to future generations and handed down in history as the land of the most expensive school system on the globe, or would it be known as the birthplace of our Franklins, our Greeleys, our Lincolns, whose school-days might be counted on the fingers?

I would not, however, be misunderstood. I do not wish to see the whole system of state instruction destroyed at one fell swoop. Revolutions, in educational as well as in political and religious systems, should be gradual, lest the destruction of an institution so interwoven with the various interests of men should prove too great a shock for the ever-frail structure of society. Even at best we shall be compelled to educate a portion of the community at public expense, so must we also feed and clothe them. This, however, is no reason why all the children of the land should be reduced to the same mental diet.

I believe that the only way in which we can hope to carry forward our civilization, or even keep it from retrograding, is jealously to guard the integrity of the individual, and to make the temple of the mind so sacred that neither law nor custom shall be able to enter and enslave. It is therefore high time to cry a halt in this rapid encroachment of the state upon the domain of the individual. It now becomes the imperative duty of every friend of America to strive to limit the state to its true function, and thus avert, if possible, those evils which have buried historic nations beneath their classic ruins. For the conclusion, however unpalatable it may be, is forced upon us, that the perfection of our system of state education implies the destruction of individuality, and that the destruction of individuality means social, political, intellectual stagnation, the last symptom of that fatal disease to which China long ago fell a victim, which is even now gnawing at the vitals of France and Germany, and of whose insidious approach America may well beware.

MORALS OF LUXURY.*

By ÉMILE DE LAVELEYE.

THE real question to be considered in discussing the ethics of luxury is, Is it useful? This question has a bearing on living issues, for it touches the foundation of the contentions which threaten civilized societies. It is well considered in the "History of Luxury"† of M. Baudrillart, who has brought to his work the result of twenty years of

* Translated and adapted from the "Revue des Deux Mondes" by W. H. Larrabee.

† "Histoire du Luxe, privé et public." Par M. H. Baudrillart, de l'Institut. 4 vol. Paris, 1878, 1880.

study in philosophy and political economy. He presents the subject in a moral and philosophical view, in the light of the history of luxury, and with the aid of the side-lights of the judgments which have been expressed upon it at different epochs, from which citations are made.

It is first necessary to understand the sense in which the word luxury is used. I designate as an object of luxury everything that does not answer to some primary need, and which, costing much money and consequently much labor, is within the reach of only a small number of persons. An extravagant consumption is one that destroys the product of many days of labor without bringing any rational satisfaction to the one who makes it, as when a ballroom queen spoils in the whirls of the dance a lace robe worth ten thousand francs, destroying in a moment the equivalent of fifty thousand hours of eye-taxing labor. What advantage does any one derive from the waste? It follows from our definition that an object may be a luxury at one time and cease to be so at another, when it can be procured without great expense. As Roscher says,* the motive here is wholly relative. Each people and each age considers that which it is in the habit of doing without as superfluous. The chronicle of Holinshed complains of the refinements of the English of his time (1577), who introduced chimneys instead of letting the smoke escape through the holes in the roof, and used dishes of earthenware or tin instead of the wooden vessels with which they had got along before. Another author of the same time, Slaney, "On Rural Expenditure," was indignant at the employment of oak instead of willow in building, saying: "Formerly the houses were of willow, and the men of oak; now it is the contrary." When calicoes and muslins were first brought from the Indies, only the rich could wear them; now working-people think lightly of them. The progress of art is thus constantly bringing more objects within the reach of the greatest number; but the definition remains that that is extravagant which is at the same time superfluous and dear.

From his analysis of the feelings which give rise to luxury, M. Baudrillart educes three which he considers natural and universal: vanity, sensuality, and the instinct for adornment. Vanity makes one desire to be distinguished and to surpass others in appearance; to pass before the crowd, that admires riches and power, as powerful and rich. When a woman pays ten thousand dollars for a necklace of fine pearls, she does not do it simply to possess something handsome and adorn herself, for false pearls would be more shapely and quite as lustrous, but because the costly necklace will be the emblem and sign of her opulence. People when they see it will say she is rich, and her lesser rivals will be jealous, adding a seasoning to her vanity. In the gratification of this feeling we seek satisfaction in a factitious existence in the opinions of other persons. It is a general sentiment, and has a

* "Die Grundlagen der Nationalökonomie," iv, 2.

remarkable power. When public opinion inclines toward virtue, it may become a stimulant for good, but will lead to luxury and corruption among a public adoring riches.

Vanity, and the love of dress that it engenders, which are very marked with the savage who tattooes before he clothes himself, become refined among civilized men and in the fashionable world, and are tempered and turned in a better direction as culture is developed and the rule of good sense becomes more influential. Formerly men, like women, wore bright goods, galoons, lace, jewels; but, since the beginning of this century, civilized nations have adopted the black coat of England; it has come to be regarded as in bad taste for a man to display jewels, and simplicity, carefulness, and extreme propriety are regarded as constituting the whole of masculine elegance. Women, however, continue to bore their ears to put rings in them, and seek to adorn themselves with trinkets of glass and metal. How may we cure this infirmity, inherited from primitive barbarism? John Stuart Mill has pointed out the way by suggesting that when woman is trained to occupy herself with affairs of the mind, she will, like modern man, cease to take pleasure in gewgaws. Christianity has already worked miracles in this direction among the Quakers and in convents: why may it not, in alliance with the culture of the reason and the sentiment of justice, do more?

The kind of luxury that has its roots in sensual seeking is harder to contend against than that which arises from vanity, because it compels us to deal with enjoyments which are real though wholly superficial. On this point M. Baudrillart remarks that as matter is finite by its nature, sensuality is limited in its capacities. Man, however, deludes himself into believing that this is not the case. It seems to him that no enjoyment procures for him the gratification it ought to give; so, when he has exhausted one, he craves another pleasure. The refinements become nicer, and new ones are demanded. Dearness heightens the enjoyment by adding to the charm of an object agreeable in itself the piquant relish of a difficulty overcome. We may give all real satisfaction to the senses without excessive expenditure. The extravagant cost is occasioned by the desire to shine, ostentatiousness, to which there are no limits. It was not in mere sensuality that Cleopatra swallowed a pearl, and Heliogabalus ate a dish of nightingales' tongues. Progress in the arts of production may bring us abundance of all that is useful; but, if the object is to distinguish ourselves from others, it is necessary to consume, at any price, what is dear and rare.

The third source of luxury is the instinct for adornment, which, as M. Baudrillart well says, must not be confounded with ostentatiousness, even when that finds its only expression in it, or with sensuality, even when it ministers to it. It is primitive with man, for the prehistorical cave-dwellers carved on pieces of bone the figures of the reindeer and beavers that lived in the land in their times. Cultivated and

refined, it has become the æsthetic sentiment, the love of the beautiful, which has created all the arts. Instead of condemning it, it is proper to encourage it and exalt it, for in public monuments it becomes an agent of civilization and a source of pure, disinterested enjoyments accessible to the whole people. Applied in private life to the decoration of houses, furniture, and articles of use, and in everything to the choice of beautiful forms, as was done in antiquity, it purifies the taste and becomes an instrument of progress. The love of the beautiful and the instinct for adornment are good in themselves, and do not necessarily urge to luxury, for it is not in the dearness of the material but in the harmony of the colors and the purity of the lines that they should be manifested. The difference between luxury and art is thus indicated by M. Baudrillart: "Art pursues the realization of the beautiful, or the reproduction of certain forms. Luxury has only one aim —to seem. The object of art is essentially disinterested; that of luxury is egotistical. In the eye of luxury, the beautiful itself, the object of the passionate pursuit of the true artist charmed with perfection, is only something that glitters. Luxury pays for art as it pays for matter, and buys great works just as it spends money for jewels and fine goods." These incentives to luxury are reënforced by the love of change, which is revealed principally in the caprices of fashion. Fashion is one of the plagues of the times, and produces evils of various kinds. First, according to the M. Baudrillart, it makes the mind frivolous by diverting it from the things that ought to occupy it. "Those who make a point of elegance are obliged to employ themselves considerably with their clothes, and to devote to them a degree of study which certainly can not elevate their minds or make them capable of great things." This is the moral evil. The economical evil is well described by M. J. B. Say: "Fashion has the privilege of throwing things away before they have lost their usefulness, frequently even before they have lost their freshness; it multiplies consumption and condemns what is still good, neat, and becoming to be good for nothing. Thus the rapid succession of fashions impoverishes a state both as to what it consumes and what it does not consume." To make a goods of silk, wool, or cotton, of a new pattern, the expense of designs, models, printing-rollers, etc., must be incurred. What is not sold during the year becomes a remnant which is disposed of at a discount. Certain styles are not to the taste of the public, and are left to be sold at half price. All of the advances and losses must be covered by the total of sales, or the ruined manufacturer will have to cease producing. The changes of fashion thus considerably augment the price of all the objects to which they apply. If the costume were not so changing, the current manufacture of the goods which it requires would be carried on at better advantage than that of the thousands of different styles that arise in the different seasons of every year.

M. Baudrillart takes a position between the rigorous school, which advocates the retrenchment of wants, and the lax school, which regards luxury as something agreeable to the person and necessary to the state, and as indispensable to the progress of civilization ; and he distinguishes between a luxury that is virtuous, permissible, and even laudable, and one which is improper and immoral. I can not admit the distinction ; and I believe that the rigorous school is right. The condemnations which have been pronounced against luxury by the sages and philosophers of antiquity, the fathers of the Church, and the orators of the pulpit, are justified by the conclusions of modern thought. These men were ignorant of political economy, but they were inspired by right instincts and sentiments.

We have said that luxury consists in the consumption, to satisfy a factitious want, of something that has cost much labor. While labor is necessary to secure the satisfaction of bare needs, and while so many men are living in almost absolute destitution, can it be legitimate to employ a great part of the forces of capital and workmen which are at our disposition in producing superfluities which we would often be better without? A thing may cost enormous sums and still be useless and even injurious. Thousands of workmen are employed in the preparation of diamonds ; but if the only use of the diamonds is to stimulate the vanity of those who possess them and to excite envy in those who have none, it would be better if they were sent to the bottom of the ocean. If the same workmen were employed in making articles of comfort for those who are in need of them, would it not be a subject for congratulation? I do not advocate sumptuary laws, but I look with pleasure on countries like Norway and the Alpine cantons of Switzerland, where, although no one buys diamonds, all have the means to procure necessaries. The real point to be considered is, that every object of luxury costs a great deal of labor ; could not this labor be made useful in a more rational manner? The truth will appear more clearly by regarding an isolated individual. Would any man devote three years to making for himself a jewel that will be of no service to him? The absurdity of the actual transaction is hidden by the appearance of an exchange and the fact that the wearer of the jewel commands it of another. If we regard humanity in the light of a man obliged to satisfy his wants by his labor, it will appear to be folly to employ a part of the time in cutting diamonds, and in return to be obliged to go barefooted another part of the time. The inhabitants of a state have the disposal of a certain number of hours in a day ; if they employ half of them in making futilities, it is evident that half the population will want for necessaries.

While M. Baudrillart condemns what he considers improper luxury with sufficient energy, he assumes that the procuring of necessaries does not afford a sufficient incentive to effort, and that a certain degree of luxury, of a moderate and moral kind, is indispensable as a

stimulant to labor. I admit, with John Stuart Mill, that it may be well to give new wants to still savage people, so that their energy and ingenuity may be stimulated and they be lifted out of a condition of indolence by the exertion necessary to satisfy those wants; but the taste for consuming is not the one that needs to be stimulated among European peoples. The greater number of men, even in a country as rich as France, have not such homes, or furniture, or clothing, or food as hygiene requires, nor such as they all certainly would desire to have. Is not this want of necessaries sufficient to urge them to labor? It is the only incentive of those who labor with their hands; and it is only those who are at ease that seek for the superfluous. "But what," says M. Baudrillart, "will you do with those thousands of artists, those hundreds of thousands of workmen, who are working in metals, in cloths, ivory, woods, gems, with infinite taste?" The eminent economist himself answers the question a few pages further on, in replying to those who say that France "produces too much." "What does this fortunate France produce too much of? It is not of the things useful or agreeable in life when there are so many poor. Let some one point out what it is that is produced in superabundance. Is it wool, when so many are cold? Is it grain, when so many are in want of bread?" Let the men who are working at ivory and gems produce the wool and the grain which you say are lacking, and the question will be answered.

M. Baudrillart regards a small number of wants as a sign of inferiority, and supposes that the development of material wants corresponds with that of the moral faculties. This is true in the earlier stages of civilization, but ceases to be so in the later stages, when the development of wants is so little a sign of progress that they have been most multiplied and refined in times of laxity, corruption, and decadence. This is exemplified and proved in the case of the Roman Empire, where the impossible was pursued, and extravagance sought the height of enjoyment in the indulgence of perverted fancies.

Economists are accustomed to measure the degree of civilization of a country by its productive power. In a certain country the rich lay the world under contribution for the adornment of their mansions and the supply of their tables, while a million poor people may be living on public charity, a third of the population may be illiterate, another third may be without necessaries, and the prisons may have to be enlarged and martial law proclaimed. No matter; that country is called the most civilized in the world. In another country, we find brawny rustics, owning their houses and lands, procuring by their labor all that is indispensable to them. No one among them falls short of a certain degree of ease and education, but no luxury can be seen anywhere. That country is considered very backward. Such are the habitual judgments of the day. I believe them to be superficial and false.

Bastiat suggests, in his "Harmonies Économiques," that we can not find a solution to the questions raised by the introduction of machinery and external competition while we consider want as an invariable quantity; we must admit that our needs are indefinitely expansible, and invoke luxury to afford an opportunity to put surplus labor to use. Machines, the economists of this school reason in effect, abridge labor; the more they are multiplied and perfected, the fewer hours of labor are required to obtain the same products. Thus the demand for hands is diminished, and an increasing number of workmen are put out of employment. In order to keep these men at work, new wants must be invented as fast as actual wants are satisfied by a smaller amount of effort, so that the hours that have been placed at our disposition may be utilized.

I claim that we ought to ask that the time that has been gained by the increased productiveness of machinery should be devoted, not to the creation of superfluities to satisfy factitious demands, but to the cultivation of the mind and the enjoyment of society and of the beauties of art and nature. At present the effect of machinery seems to have been not to shorten but to lengthen the hours of toil, and to extend them through the night, and to make life more intense and cause a greater expenditure of nervous force.

To satisfy our rational wants we require food, clothing, and habitation suitable to the climate and season; to these we may add the cheap accessories which the progress of industrial art has put within the reach of all. The line between a consumption that is reasonable and one that is not so may be found in every case by answering the question whether the satisfaction which the desired object will procure is worth the time and effort necessary to produce it. If it is, I am right in procuring it; but, if to get it I have to divert human labor from a more useful destination, I am wrong. I sacrifice what is necessary to what is superfluous. M. Baudrillart regards everything superfluous as a luxury. I agree rather with M. J. B. Say, who thinks it must be also dear. Thus, a Japanese fan costing a cent or two and a cheap looking-glass are superfluous; but, as it costs but little effort to get them, the satisfaction they afford is quite worth the expenditure. When the countryman drinks his wine which he would sell, perhaps, at four sous a quart, it is not extravagance. When a Crœsus drinks Johannisberger at eight dollars a bottle, the expense is relatively little for him; but he has, nevertheless, consumed the equivalent of twenty days of labor, which have been taken from the whole of the time available to humanity for the satisfaction of its essential wants, and for what advantage? Only to secure the fugitive taste of a flavor that is hardly appreciable to the finest palates. No one will hesitate to say that the time has been put to a bad use. The fact escapes the world under the complications of exchange; nevertheless, people have an intuition of it, for they often blame certain

foolish expenditures even when they are incurred by those who can afford them.

We may consider luxury from three points of view: First, from the moral point, as concerning the individual; within what limits is the perfect satisfaction of wants useful in the normal development of the human faculties? Second, from the economical point; to what extent is luxury a help or a hindrance to the increase of wealth? Third, from the point of right and justice; is luxury compatible with the equitable division of products, and with the general principle that the remuneration of each person ought to be proportional to the amount of useful labor that he has performed? The third aspect of the problem has hardly been appreciated, because it has never been clearly seen that juridical principles should be applied to the economical repartition of products. We should not forget, however, that Christianity, having made charity a duty, has always condemned luxury because it devotes to superfluous and therefore immoral expenditure that which ought, according to its principles, to be given to the poor.

Putting aside the consideration of what man owes to his fellows, and what charity and justice expect of him, let us see whether luxury is good or injurious to the individual. The end to be pursued by man in his life is the normal development of all his faculties and the happiness that should result from it. It includes the perfection of his physical and intellectual forces, of his sentiments, of his affections in the family and toward his race, and the enjoyment of the beautiful in nature and art. Modern luxury, with the multitude of efforts required to satisfy its demands, opposes a double inconvenience against the attainment of these objects. Time has to be consumed in gaining the money that its futilities require, and the leisure that is left after the money is got is employed in expending it upon them. The whole man is thus entangled in a wheel-work of material pursuits, and can afford nothing for the life of the mind and the heart. Consider the life of that financier who counts his millions by the hundred: his transactions, his calculations, his business associates, take up his whole day; and even in the evening, among pleasures which he seeks and does not enjoy, he is still thinking about operations that may increase that fortune the revenue of which already surpasses by many times the cost of all the wants that he can dream of. He may be said to be loaded down under the mass of his property. He may be without doubt a useful wheel in the general work of production, but is he on the road that leads to perfection and happiness? The man without wants is without cares, and may be gay as the lark all the day. By help of the gifts of science and art we are able to produce so much wealth that we are confounded at the sight of the figures by which it is measured in the statistical tables; and still our age is preoccupied, tense, and melancholy.

Bossuet treats this point in his "Traité de la Concupiscence" in language of great force: "The body," he says, "humbles the sublimity of our thoughts, and attaches us, who ought to breathe of heaven, to the earth. . . . Why," he continues, "do you turn your necessities into vanity? You need a house as a defense against injury from the weather—it is a weakness. You need food so that you can repair your forces, which are wasting away at every moment—another weakness. You need a bed where you can rest in your weariness and give yourself up to a sleep that chains and overwhelms your reason—another deplorable weakness. You make of all these witnesses and monuments of your weakness a spectacle for your vanity, and it seems as if you wished to triumph with the display of the infirmities that environ you on every side." Bossuet, it may be, carries the doctrine of renunciation to asceticism, but is he not right in the main? Is not every one of our needs a weakness, a subjection, a temptation to sacrifice the good and the just to sensuality? Dignity of bearing, pride in conduct, fidelity to opinion, often depend on simplicity in life. The fewer wants one has, the freer will he be to do whatever duty commands, and the less will he have in important crises to listen to the suggestions of cupidity.

The opinion that luxurious expenditure promotes the prosperity of the people is an error of the most pernicious character. Those who indulge in superfluities imagine that they are doing a service to the working people, and governing bodies, sharing in the delusion, sometimes grant special appropriations to induce certain functionaries to set the example of costly outlays. The most elementary notions of political economy should show this idea to be false. The progress of industry depends on the increase of capital, and capital grows with saving. Luxury does not promote the increase of wages, but opposes it. Wages can only rise when capital increases faster than the number of workmen, or, as Cobden says, when two masters are running after one workman. Now, in order that this may take place, each of the competing employers must have accumulated a capital by saving. It is thus saving, not superfluous expenditure, that permits the creation of new fabrics and the employment of more workmen. In very rich countries, indeed, luxury does not prevent the increase of capital, because the incomes are sufficient there to answer for both purposes. Those who save are found in those countries along with those who spend, and the possessor of a large income may easily indulge some of his fancies and still save considerable sums. The immense surplus revenues of England are employed in the creation of new enterprises at home and abroad; but, if thrift were more general in that land, its productive capital would be still more largely increased and more widely distributed.

It is claimed, as a thing that is admitted by every one, that luxury stimulates trade. J. B. Say shows up this doctrine with the story of

a rich uncle of his, who, after dining, broke his wineglasses, saying that the world must live. Say wondered why it would not be as well to break the rest of the furniture, to help more of the world's workmen to live. According to this view, Nero was inspired by true economical principles when he sung over the burning of Rome. M. de Saint-Chamant once remarked that, if Paris should be destroyed by fire, he would deplore the event as a citizen, but rejoice over it as an economist, for it would give an extraordinary bound to labor. If the doctrine be true, political economy should be the science, not of the production, but of the destruction, of wealth. The error arises from regarding labor rather than its results as the chief object.

To clear up this error, it is necessary, as Bastiat says, to distinguish between what we see and what we do not see. We see the workman who is engaged in replacing what has been destroyed, but we do not see the other workman who might have been employed to make something else with the money which we now have to apply to the payment of the former workman. Say's uncle certainly furnished work to the glass-factory, but if he had saved his glasses he might have spent the same amount of money in buying other things, and himself had more objects, while the wealth of the state would have been increased. Many hands were employed in rebuilding the monuments that were destroyed in Paris in 1871; but with the money that was thus spent other monuments, schoolhouses, or railways, for example, might have been built, and at the closing up of the account Paris would still have had its palaces, and the state would have gained new halls of instruction and new means of transportation.

It may be urged that, if our theories are carried out, hosts of tradesmen and artisans will be condemned to starvation. The value of this objection may be illustrated by an hypothetical example in life. A wealthy banker spends immense sums in feasts, and induces his friends to spend three or four times as much as he does. The dealers to whom patronage is given accumulate great sums. The public is charmed, trade flourishes. Now comes a preacher thundering against luxury, and instigating a revival of frugality. Balls and feasts are given up. What will be the result of the change? The banker and his friends are not going to throw their money away or let it be idle, but will do something with it to make it return a profit. One will improve a long-neglected piece of land, will plant and drain it, and repair the buildings; another will enlarge his factory, and a third will undertake railway contracts. All will make work, and that of a useful and productive character, so that they may receive interest for their outlays. The same amount of money is spent, and it supports the same amount of work and gives a living to the same number of workmen, only they are employed in the fields, where they are not seen, instead of being engaged in the fashionable shops, where they are always before the eye of the public. Now look at the difference in the effect on the

wealth of the country. When the ballroom lights were put out, what was left? Nothing but rumpled vanities, deranged stomachs, and overtaxed nerves. The capital of society has been twice diminished: in the expenditure of money and the waste of human force. On the other hand, when the useful enterprises which have given as much work are finished, there remain a field better drained and manured and bearing more grain, a better planted forest furnishing more wood, a new factory turning out more goods, and a new railway line. The country is enriched and produces more. In the next year the workmen are better provided for, their expenses are lessened, more hands are needed to keep the increased capital employed, and wages are raised. A profit has accrued on both sides. The application of means to the production of necessary and useful objects has the additional advantage that the demand for such objects is more stable, that they are not so readily dispensed with in times of retrenchment, and are not so subject to the changes and caprices of fashion.

It is further pleaded that luxury makes money circulate. This, also, is unsound. Circulation of itself brings no profit. Money nowhere circulates faster than on the green cloth of the roulette-table. Some lose, others gain, millions; but what is the profit to the country? Money is all the time in circulation, unless it is buried in a pot. The important matter is, whether in passing from hand to hand it commands permanent ameliorations and satisfies the real wants of men, or whether it is wasted upon the futilities that minister to pride and ostentation.

The crowd approve the letting off of expensive fireworks, and believe that the money they cost is still in the country, and that nothing is lost. But there were in the country two capitals: one of money, the other represented by powder, which might have been employed in extracting coal and minerals from the earth, or in works for railways. The second capital has vanished in smoke, and only the money is left. Consumption is always destruction; it is important to see that for this destruction is returned as compensation some satisfaction of real wants, or the creation of some new means of production. Consumption is in reality a barter. We give up an existing value; if we receive in return something to strengthen the body and exalt the soul, we have done well; if something to stimulate pride and vanity, it is worse than nothing, and we have done ill.

We may regard luxury, in the third place, from the juridical side, and ask if it is compatible with right and justice. All Christian tradition answers the question in the negative. The Scriptures abound in passages condemning the egotistical and unregulated employment of riches. The fathers of the Church insisted upon a kind of equality of right, and urged that those who have a superfluity can not legitimately dispose of it for themselves, but ought to share it with those who are in want of necessaries. The Church has indicated alms as the

single remedy for inequality of wealth and its resultant luxury. What is to be done, however, now that political economy has demonstrated, from the evidence of facts, that alms engenders idleness, mendicity, indolence, and debasement of character, and that it is fundamentally wrong, because it levies an impost on those who work for the profit of those who do not work?

The true solution of the question is to be found in encouraging the greatest possible number of citizens to become holders of property. Let it be in the power of each one to secure a parcel of land, a bond, or an industrial obligation, a little capital in some form, so that property may become democratized, and extreme inequality will be caused to disappear; then, if the progress of mechanical arts induces the multiplication and refinement of products, they will be within the reach of all. Such conditions still prevail in countries where the agrarian customs and the proprietary forms of primitive times have not been destroyed by the civil laws and feudal and royal usurpations.

Voltaire says on this subject, in his "Dictionnaire Philosophique": "If we understand by luxury all that is over and above the necessary, it is a natural consequence of the progress of the human species, and by a consequent reasoning every enemy of luxury should believe, with Rousseau, that man's real state of happiness and virtue is not that of the savage, but of the orang-outang. We feel, however, that it would be absurd to regard as evils such conveniences as all men enjoy; so we generally give the name of luxury only to the superfluities which are within the reach of but a small number of persons. In this sense, luxury is a necessary concomitant of property, without which no society can exist, and of a great inequality in fortunes, which is the result, not of the right of property, but of bad laws. It is, therefore, bad laws that generate luxury, and it is good laws that must destroy it. Hence, moralists should address their remonstrances to legislators, not to individuals; for it is in the order of possible events that a virtuous and enlightened man should have the power of making reasonable laws, but it is not in human nature that all the rich men of a country should virtuously give up the enjoyment of buying pleasure and vanity at the price of a small sum of money."

One kind of luxury only, in my opinion, is justifiable: that, namely, which admits the public to its enjoyments; which invites the masses to the pleasures of public gardens and fountains, which places the beautiful within the reach of those who can not own statuary or pictures, by establishing museums of art, and which founds libraries and public expositions. Such collective luxury, if well directed, is profitable to all. It raises the level and fecundates the genius of industry. The duty of the easy classes in every country is to favor those movements which will tend to enable all of the people to become possessors of property, and themselves to set the example of application to labor, rural tastes, simplicity of life, and high moral and intellectual cul-

ture. Those who have the disposal of the superfluous produce of the country should employ their wealth not in refining material enjoyments, or in stimulating the unhealthy gratifications of vanity and pride, but in works of general utility, as many an American citizen and more than one European sovereign have done.

MIND AS A MEASURE OF NATURE.

By CHARLES T. HAVILAND.

IT has been said that every man is born a Platonist or an Aristotelian. This is an epigrammatic way of stating the fact that the general tendency in the pursuit of knowledge is to approach it from one or the other of two different standpoints, variously called the subjective and the objective ; the mental and the material ; the theological, or metaphysical, and the scientific. While this tendency is pretty clearly marked, yet the saying has the fault common to most apothegms, of sacrificing correctness to brevity—of overlooking the delicate gradations in Nature's continuity in its attempt to express her more salient diversities in a pithy utterance. This is the imperfection of all classifications. They necessarily separate what is continuous. It is only as they refer to genetic relationships that they most nearly correspond with nature, and this they can do in only a few of the natural sciences. For the most part, the act of classifying is the application of a mental scale to incommensurable quantities. The very impossibility of grouping phenomena into natural kinds renders an artificial classification necessary. Before science can advance a single step, the innumerable phenomena of nature must be reduced into classes. If not susceptible of natural arrangement, they must be arranged artificially ; and, as long as the artificial character of the classification is comprehended, no harm is done ; but when men, with but little knowledge of the objects dealt with, proceed to construct a procrustean bed to which they expect Nature to conform, and then, from this tortured witness, attempt to extort unwilling testimony, they may expect Science to enter a demurrer. As this method, however, has the merit of simplicity, as might be expected, it has long been the favorite with a certain class of philosophers.

Turning back to the early progress of human speculation, especially so far as it has reference to material objects, we see that all the first attempts at physical knowledge consisted, principally, of deductions from mental notions, with but little, if any, reference to phenomena. Beginning with the theories of the universe propounded by the Greek philosophers, we see that whatsoever progress was made in scientific acquisition was only in proportion to the occasional reactions from the

excessive subjectivity that mostly prevailed. This reaction found expression in men like Archimedes and Hipparchus, and under their influence science had apparently attained a foothold when the intolerance of a religious supremacy, which held sway over Europe during the dark ages, banished it from Christendom, and thus became debited to humanity for a thousand years of stagnation.

Not until the time of Copernicus was there any new impetus to research. The appeal to objective facts was, then, although in a small degree, made the avowed basis of scientific speculation. Then began the progress of knowledge which, with constantly accelerating speed, has continued to our times, and which, we trust, may not again be slackened.

The experience of our predecessors teaches us a lesson that we ought not soon to forget. In the practical affairs of life, experience is considered the best guide. The man who learns nothing from its teachings does not succeed. It is no less important in the life of the race. If we learn nothing from others' failures, we can expect to learn nothing from their successes.

The attempts to construct the universe *a priori* are analogous to the attempts to construct a perpetual motion. As long as there was no direct reference to experience, it appeared by no means improbable that a machine might be so constructed that, when once set in motion, it would never stop. Any one, who has had any experience with a class in mechanics, knows how crude are the notions they possess with reference to the very elements of physics. It is safe to assert that today not one person in ten possesses a thorough certainty of belief in the validity of the third law of motion, namely, that action and reaction are always equal; or, to put it in more familiar language, that, when a horse pulls a wagon, the wagon pulls the horse equally hard. It is not until correct mechanical notions become wrought into the very warp and woof of one's mental fabric that his deductions from them may fairly be presumed to be correct. Witness the absurd notions current only a very few years ago as to the possibility of constructing a "motor" that should, in some mysterious way, evolve force enough from a pint of water to propel a train of cars from Philadelphia to New York! Mechanics went on inventing "perpetual motions," but, however plausible they looked, somehow or other they wouldn't work. Do away with friction to the greatest possible extent; overcome one obstacle here and another there; increase the time the machine would run indefinitely—still, to a state of equilibrium would it come at last. From these empirical observations mechanics learned, what philosophers might have learned years ago, that experience affords the only sure test of the validity of our notions.

After numberless failures had taught the empirical lesson that attempts to construct a perpetual motion were fruitless, the gradual development of the law of the conservation of energy showed the reason

for it. In like manner, we have sufficient reason, judging merely from the observation of previous speculation, to warrant us in abstaining from attempts to deduce a knowledge of material nature from mental concepts. Add to this fact that other, that all knowledge has its basis in experience, and we supplement our empirical conclusion by a deduction from a fundamental law of nature, and show their entire congruence.

Early physical speculation, with hardly an exception, proceeds on the assumption that knowledge is derived primarily from the mind—thus completely inverting the true order. Would some of those persons who in our day attribute so much power to the unaided mind carefully peruse a history of science in the early centuries of our era and the centuries immediately preceding it, we think they would become convinced that purely mental speculation can never lead to any exact knowledge, but must, on the contrary, invariably be a source of obscurity and error.

With but two or three exceptions, the most eminent men of the early and middle ages, except as in a few instances they recorded interesting facts, contributed absolutely nothing to scientific progress. The principal cause of the difference in the civilization of our times and those of the ancients is the progress of exact knowledge. What would the most mystical of metaphysicians of to-day say to Socrates's assertion that those things are called like which partake of the quality of likeness? or to Aristotle's argument against a void in nature, that a void is a negation, and in a negation there could be no differences, and where there were no differences there could be no up or down, consequently bodies could not move up or down in a void, but it is the nature of bodies to move up and down, therefore there is no void? or to his argument in support of circular motion, that it is the best, therefore the most natural? The mental ability of the "Father of Logic" is unquestioned. He follows logical methods closely enough. What, then, is there unscientific in his reasoning? Simply that he allows abstract terms and mental notions to pass current for facts—thus using an irredeemable currency as though it possessed intrinsic value.

The modern astronomer can not but wonder at the daring speculations of the Pythagoreans, that, as ten was a perfect number, there must be ten heavenly bodies, notwithstanding nine only were then known. Before such vaticinations the predictions of a Leverrier sink into insignificance.

We find the whole history of science, up to the time of Copernicus, a history of the conflict of facts with preëstablished notions. The problem of astronomers was to reconcile the apparent motions of the heavenly bodies with their assumed circular motions. Thus, when it was found that the motions of the planets were not uniformly circular, it was naïvely suggested that an uncertain motion could not be

tolerated even in a man, much less in a planet, hence the theory of epicycles, or wheels revolving on the rims of other wheels, was introduced. Notwithstanding its questionable parentage, and the fundamental error on which it is based, this theory, as established by Hipparchus and extended by Ptolemy, is about the only example of a scientific working hypothesis previous to the fourteenth century.

Physics, equally with astronomy, suffered from the anti-scientific method. The study of nature was not only neglected, but discountenanced by the Church. *A priori* arguments were urged against the existence of antipodes, and, but a short time before they were visited by Columbus, a belief in their existence was denounced as heretical. The direction of knowledge during the middle ages was retrogressive rather than progressive. Scholastic physics was based upon the assumption that analysis of mental concepts would give all requisite knowledge. Why wonder at the result? Weight being the cause of bodies falling, it was assumed that heavy bodies would fall faster than light ones. Personal qualities being attributed to inanimate objects, there were supposed to be different degrees of perfection in the metals, and thus arose alchemy, whose aim it was to extract gold—the most perfect metal—from the baser metals.

The contagion of scholasticism became epidemic, even infecting able men, and establishing its parasitic growth upon sound theories. Astronomy gave birth to astrology, to whose weird influence even a Bacon could succumb. One of the arguments brought forward in support of the Copernican theory was that it placed the noble element, fire, in the center of the universe, thus satisfying the tendency toward mythical explanations. So prevalent was this method of considering nature, that Kepler himself entered into complex speculations concerning the relations of music to the motions and distances of the planets; and even Galileo was led into an erroneous theory of motion in consequence of assuming that it must be the simplest possible. In support of true hypotheses, as well as false, metaphysical reasons were given. The fact that from them anything wished for can be proved, constitutes the great danger in their use. From the immutable laws of God Descartes deduced the first law of motion, while, from the same source, the Church had previously demonstrated the immovability of the earth. Borelli conjectured that the motions of the planets were controlled by two forces—one the centrifugal force, and the other the appetite a planet must have for the body about which it revolves. Suction was explained by the famous principle that Nature abhors a vacuum, and, had it not been discovered that the abhorrence ceased at certain fixed limits, this explanation would probably have done service even to our day, for that class of philosophers for whom the kindred principle of vitality is a sufficient explanation of the various phenomena of life.

The few examples that have been cited give a fair sample of the science of the middle ages. During that long period the men imbued

with a spirit of scientific research could be counted on one's fingers. It is a striking fact in the history of man that, out of the many centuries he has inhabited the earth, so few have been productive of any useful knowledge. Throw away everything that had been done previous to the fifteenth century, and the loss would have been by no means irreparable. Add to the productive period twenty centuries, and we embrace the whole. Think of the average life of fourscore men spanning the totality of human knowledge! Truly, science is in its infancy. What were the speculations of the men who existed a few centuries prior to our era, we have no record. After the dim poetical aspirations which compose the earliest known philosophy, there emerges a pseudo-scientific natural philosophy, which, disdaining the shackles that a constant reference to the phenomena of nature would impose upon its flights, attempts at once to solve the problem of the universe. Like the famous German, who, instead of going to see the camel he was to describe, pursued the easier and more fascinating method of evolving him from his own inner consciousness, the Greek philosopher evolved the universe from his.

A modern writer, who certainly can not be accused of want of sympathy with a deductive philosophy, in comparing the relative merits of the *a priori* and *a posteriori* methods, observes that, although the latter may in general come somewhat nearer the facts of nature, yet, as it can never embrace *all* the phenomena in its inductions, it can never arrive at the whole truth; while the *a priori* method, if it chance to hit upon the right formula, has the whole universe, so to speak, at its fingers' ends. While we may readily admit the sublimity of the attempt to reach out and grasp the hidden springs of nature, stubborn facts constrain us to assert its impracticability. The diffuse light of mental theory must be concentrated to a small focus in order to produce any visible effect.

Knowledge is the concomitant of the progressive limitation of our powers. As long as man assumes that he contains within himself the premises of knowledge, so long will it elude his grasp. Not until experience has compelled him to doubt the validity of his mental concepts when applied to nature, and has forced him to have recourse to facts only, has man taken the first steps in the paths of science.

That one learns the boundlessness of knowledge only in proportion to his own acquirements is a saying famous only for its triteness. What are certainties to the ignorant are uncertainties to the intelligent. What are dogmas to the blind followers of a fanatical priesthood are for ever insoluble problems to the man of science. The ignorant savage—who can not count beyond five; who has no abstract names in his vocabulary; who knows nothing of the use of pronouns; who uses words denoting the commonest things and most usual actions only—possesses knowledge differing so widely in degree from ours as almost to constitute a difference of kind. For him nature has no problems.

The universe, of which he knows so little, is but in a slight degree a mystery. Wonder—the first sense of philosophy, as it has been so aptly termed by Aristotle—exists in his mind only as superstition. We are too apt to think that primitive or savage man must be appalled by the presence of nature, forgetting that his universe is limited to his own unaided senses. We forget that, in our own life, philosophic problems present themselves only as we approach maturity, and, generally, then only if our studies have led us in their direction. To see how little the "natural man" comprehends these problems, observe the answers he gives to those questions in which it is customary to assume that the wayfaring man, though a fool, does not err.

Man is naturally a "realist." Things *are* to him what they seem. Mind is his sole measure of nature. He looks nowhere else for an interpreter, and knows no other source of knowledge. He interprets natural phenomena by mental qualities, and this prepossession colors all his theories. The history of science is the history of the gradual demolition of this tendency. The mental distance from a savage that personifies the tree, the forest, and the stream, to a Kepler that conceives it necessary to place a guiding spirit in the planets to keep them in their courses, is, of course, immense, and each is indicative of the thought of his time; but we now know that each was in error in positing some utterly unknowable substance to explain the unknown elements.

The person who to-day expects to make the phenomena of life more clear by attributing them to the effects of "vitality" is making a dangerous mental concept do duty in place of exact knowledge, however limited. The frequency with which this attempt occurs, even among men eminent in science, shows that continued protests are needed. However little real knowledge we may possess upon a given subject, our only way to get more is to approach it humbly and laboriously as a question that can be solved only by constant reference to the facts that appertain to it. All experience teaches that an analysis of mental notions has never yet yielded a particle of natural knowledge, but, on the contrary, has often proved a barrier to the acceptance of true theories. We can not expect to be more fortunate ourselves. The principal objection to the development theory has been on the ground of its opposition to preconceived notions as to the reality of the mental conception "species," and to certain beliefs in vogue concerning the genesis of man, rather than to its assumed opposition to the facts of nature. Every theory has to run the gantlet of this extra-scientific criticism, and only when it is shown to have no possible bearing upon preconceived notions is it allowed to be settled simply upon its merits and by scientific methods.

Instead of reverting to the experience of our ancestors and showing the futility of all previous attempts to extract light from mental sunbeams, we might have deduced the same conclusion from the known

laws of thought. No psychological theory has greater probability than that which bases the units of knowledge in experience. Since the time of Locke and Hume, the drift of speculation has been steadily in the direction of a more or less modified empiricism. The more far-sighted of the intuitionists cast aside everything they thought could embarrass their theory, and were content to allow that the matter of thought was based upon experience, while reserving as the province of intuition the mental forms by which knowledge was possible. The theory of evolution explains this intuitional residue by extending the experience of the individual to the experience of the race, and showing that what may be intuitive (in every sense, except the supernatural, in which that word was formerly used) to the individual is so in consequence of inherited tendencies corresponding to the aggregate experience of his ancestors.

But we do not need to urge mental theories, however probable, to show that our knowledge of the universe is dependent upon our surroundings. A little difference in the physical condition of the earth would have sufficed to have utterly changed our conception of nature. Make the not very inconceivable supposition that our earth bore the same relation to the sun that the moon does to the earth—rotating once on its own axis to each revolution about the sun, and remaining nearly perpendicular to the ecliptic, thus always presenting the same side to the sun's rays—how would it have affected our knowledge of nature? To what modest proportions would not only science have shrunk, but also our mental or intuitive conceptions of nature!

Astronomy has been well called the mother of the sciences. The apparent motions of the sun, moon, and stars through the heavens, and the motions of the planets among the stars, contributed to produce a wonder in the minds of the beholders that might well cause astronomy to be the first studied of the sciences. In our hypothetical world, the sun would appear stationary in the heavens, more or less removed from the zenith according to the position of the observer. On the center of the earth's surface would be a torrid zone upon which the vertical rays of the sun would pour down with unremitting severity, with no alternation of day and night to temper its influence. Outside of this would be a temperate zone well adapted, it might be, to the existence of human beings, but having no change of seasons, only one monotonous summer day, varying in temperature according to location. The temperate zone would gradually give place to a frigid zone, and, as the day darkened into an eternal night, this would be succeeded by an impenetrable region in which the degree of cold would vastly exceed anything we have on earth at present. Thus man, confined to somewhat less than half the globe, would see nothing of the moon or stars, and the earth, with the sun shining on it, would be the only bodies visible. There would be no natural divisions of time into days, weeks, months, or years. Mathematicians might calculate the hemispherical

form of the earth, but the elephant and the tortoise would be more than ever necessary to support it. There would be no science of astronomy, no knowledge of the law of gravitation, none of physics, so far as it was dependent upon astronomy. The sciences so act and react on one another that it is difficult to say just how far the absence of one would affect the others, but we know it would greatly. Such suppositions as we have made may be more or less fully realized in other worlds, and we can thus see that their science may differ very widely from ours and still be no less correct. Science is everywhere relative to the facts with which it has to deal. The difficulty of conceiving physical and spatial relations different from those we are familiar with does not prove them non-existent; nor does the ease of such conceptions prove their existence.

Helmholtz has very ably shown that our geometrical axioms have a truth relative only to the space they are applied to. He supposes beings, of the same mental capacity as ourselves, but of two dimensions only, to inhabit a plane surface. They would possess a plane geometry like ours, but would have no solid geometry whatsoever. Thickness would be as inconceivable to them as a fourth dimension in space is to us. Transplant these beings to the surface of a sphere, and their planimetry would change to a spherical geometry. Defining a straight line as the shortest distance between two points, all their straight lines would be arcs of great circles, and every straight line, when sufficiently extended, would return to itself. Between two points, half the circumference of a great circle apart, an infinite number of straight lines, of equal length, could be drawn; and, as two points would always cut the great circle on which they were situated into two arcs of unequal length, there would always be, besides the shortest straight line connecting the points, a longer straight line (i. e., a line made up of shorter lines, each of which is the shortest distance between its extremities) also connecting them. There could be no parallel straight lines and no similar triangles. The sum of the angles of a triangle would always be more than two right angles, and the amount of the excess would depend upon the length of the sides.

Helmholtz again supposes these beings of two dimensions to be placed upon (what has been called by Beltrami) a pseudo-spherical surface—a surface shaped somewhat like the sides of an hour-glass. Here our axiom of parallels does not hold good. Through a given point, a whole pencil of straight lines may be drawn, none of which shall cut a given line, though infinitely produced, and limited, at the two extremes, by lines that cut the given line at infinite distances in the opposite directions. Helmholtz makes other suppositions which it is unnecessary to follow, as we have already gone far enough to show that even the fundamental axioms of geometry are quite as dependent upon the conditions under which they are used as upon any intuitive necessity we may think belongs to them.

It is well known that but a portion of the phenomena of nature are cognizable by us—how small a portion it is not known. A person born blind has no conception of color; one born deaf, none of sound. The disease of color-blindness affords a good illustration of the limitation of knowledge in consequence of the limitation of sensibility in certain directions. One affected with this disease, while able to see outlines with perfect distinctness, as well as some of the colors, is insensible to others; and this insensibility does not affect alone the ability to discriminate between colors nearly alike, but also those that are apparently widely divergent. It is related of Dalton, from whom color-blindness takes its name of *daltonism*, that some wag exchanged the robe of sober drab which this demure Quaker was in the habit of wearing, for one of scarlet, and that, unconscious of the difference, he went forth, much to the amusement of the bystanders. Undoubtedly many accidents are due to the inability to discriminate between different colored signals. This subject is just beginning to receive the attention its importance demands, and it is found much more prevalent than was even suspected. Like short-sightedness and, probably, all maladies due to the absence or the imperfection of any of the senses, the subject of it is unconscious of its existence until something particular calls it to his attention. To a greater or less extent we may all be said to be color-blind. Only a part of the rays that are known to proceed from the sun are visible to any of us. Vision is produced only by waves of a certain definite length. The rays of longer wave-length than the red are known to us by their heat-producing effects only; those of shorter wave-length than the violet, by their chemical effects. It is not improbable that, at some future time, a race may exist capable of seeing rays invisible to us—just as we perceive many invisible to some of the lower animals. In the development of sight there must, at first, have been simply a power to distinguish light from darkness; then, the ability to distinguish outlines; and, finally, the sensibility to color. Until this sensibility was developed, objects would present merely an alternation of light and shade, similar to the view we get in a stereoscopic picture.

Sounds inaudible to us are heard by insects, and odors that we can not distinguish are smelled by animals. So we might go through the whole category of sensations and resulting ideas, and show their variation under different conditions; and yet, whatever may be the theory of knowledge we espouse, it is from these sensations and ideas that we form our conception of nature. How different our mental conceptions would be if our senses were indefinitely magnified, we can but guess. A drop of water, it has been estimated by Sir William Thomson, if magnified to the size of the earth, would be seen to consist of molecules of the size of cricket-balls; and these molecules are themselves of great complexity. The internal motions of a drop of blood are more complex than the motions of the solar system. Place

it under a microscope of high power, and the corpuscles are seen hurrying hither and thither as if (to use a quite appropriate simile) their life depended upon it. Repeat the process, and new complexities are seen. Increasing the power of our senses artificially by the use of instruments has given us a vastly enlarged conception of nature; but every increase in knowledge shows us more clearly the limitation of the knowledge we possess. Truly, there are more things in heaven and earth than are dreamed of in our philosophy.

Science is continually teaching us the lesson that the universe is larger and more complex than formerly supposed. Old geographers, guided by an egoistic impulse, placed their own country in the center of the known earth; early astronomers placed the earth in the center of the universe. Later, that position of honor was given to the sun. The influence of mental concepts and the desire for system, even where none is discernible, induce some astronomers to locate the center of the sidereal system somewhere in the region of the Pleiades; but, even should this attempt prove successful, we should be no nearer the discovery of the center of the universe. Place a grain of sand thirty feet from an orange, and you have, approximately, the relative distances and dimensions of the earth and sun. Nearly one thousand feet beyond would be the planet Neptune—the outermost planet of our system—while more than twelve hundred miles would have to be traversed before arriving at the nearest fixed star. Even on this miniature scale, our fractions of inches grow to miles, and man finds himself immeasurably dwarfed, even in the presence of the known. He sees whole systems drifting through space. In a much broader sense than Emerson meant, we are like ships upon an unknown ocean, knowing neither whence we came nor whither we are bound.

It is fascinating, no doubt, to construct theories of universe-reaching proportions. It has been truly said that—

> " . . . Our nimble souls
> Can spin an insubstantial universe
> Suiting our mood, and call it possible,
> Sooner than see one grain with eye exact,
> And give strict record of it."

Perhaps such employments are elevating. Such, at least, is the claim of those who affect to despise what they superciliously term the bread-and-butter sciences. Admit all they claim; still, their conceptions of nature are worthless until verified.

In this brief sketch of past thought, we have seen that it was only as man has been content to acquire knowledge patiently, slowly, and arduously, by what are now known as scientific methods, that his knowledge has been of any practical value. Theorize as widely as he may, constant verification is the only criterion of a theory's validity. Fact must be the point of departure and the point of return of all

theories. Mental notions can aid us only as they are reflections of nature. Even scientific hypotheses have but a relative validity. In time, as in space, the extent of knowledge follows a law analogous to the law of spherical diffusion. It has been held that the record of any historic event is wholly invalidated by the lapse of sufficient time; much more is this true of future prediction. The base-line of our knowledge is sufficient but for a limited survey. The very distant future has no mental parallax.

We have seen every far-reaching theory become obsolete; and there is no reason to suppose that, at the present time, we shall be more successful. There is but one course that it is safe to pursue, namely, to be content to let insoluble problems remain as such—not attempting any mental theory concerning them—and confine ourselves to those problems that may offer some probability of solution, with the assurance that, however far the boundaries of knowledge may be extended, each successful solution will enlarge the horizon of the unknown beyond.

SKETCH OF PROFESSOR BENJAMIN PEIRCE.

THIS illustrious American mathematician and astronomer died in Boston, October 6, 1880, in the seventy-second year of his age. He was born in Salem, Massachusetts, April 4, 1809. He was graduated at Harvard College at the age of twenty. His father was a graduate of the same institution, and died its librarian. He was appointed tutor in 1831, University Professor of Mathematics and Natural Philosophy in 1833, and Perkins Professor of Astronomy and Mathematics in 1842, and was directly connected with the faculty of the college for forty-nine years. He was a member of all the learned societies in this country and in Europe, was elected Fellow of the Royal Society of England in 1857, and in 1867 received the degree of LL. D. from Harvard University.

We take the liberty of quoting from that excellent periodical, "The Harvard Register," for May, 1880 (to the courtesy of whose editor we are also indebted for the excellent likeness herewith presented), the following account of Professor Peirce's character and work, written, it will be observed, before his death, by Dr. Thomas Hill, ex-President of Harvard University:

"From 1836 to 1846 he issued a series of text-books on geometry, trigonometry, algebra, and 'curves, functions, and forces.' They were so full of novelties that they never became widely popular, except, perhaps, the trigonometry; but they have had a permanent influence upon mathematical teaching in this country; most of their novelties have now become commonplaces in all text-books. The introduction

of infinitesimals or of limits into elementary books; the recognition of direction as a fundamental idea; the use of Hassler's definition of a sine as an arithmetical quotient, free from entangling alliance with the size of the triangle; the similar deliverance of the expression of derivative functions and differential coefficients from the superfluous introduction of infinitesimals; the fearless and avowed introduction of new axioms, when confinement to Euclid's made a demonstration long and tedious—in one or two of these points European writers moved simultaneously with Peirce, but in all he was an independent inventor, and nearly all are now generally adopted.

"All his writings are characterized by singular directness and conciseness, and particularly by a happy choice of notation—a point of great importance to the mathematician, lessening not only his mechanical labor in writing, but also his intellectual labor in grasping and handling the difficult conceptions of his science.

"His text-books were also complained of for their condensation, as being therefore obscure; but, under competent teachers, their brevity was the cause of their superior lucidity. In the Waltham High School his books were used for many years, and the graduates attained thereby a clearer and more useful applicable knowledge of mathematics than was given at any other high school in this country; nor did they find any difficulty in mastering even the demonstration of Arbogast's Polynomial Theorem, as presented by Peirce. The latter half of the volume on the Integral Calculus, full of marks of a great analytical genius, is the only part of all his text-books really too difficult for students of average ability.

"Gill's 'Mathematical Miscellany' contained many contributions which showed in a singular light the Harvard professor's power. For example, in the issues for May and November, 1839, he solved, by a system of coördinates of his own devising, several problems concerning the involutes and evolutes of curves, which would probably have proved impregnable by any other mode of approach.

"During the year 1842, Professors Peirce and Lovering published a 'Cambridge Miscellany of Mathematics and Physics,' in which Peirce gave an analytical solution of the motion of a top, a criticism of Espy's theory of storms, etc. About the same time he adapted the epicycles of Hipparchus to the analytical forms of modern science; and the method was used by Lovering in meteorological discussions communicated to the American Academy.

"The comet of 1843 gave Professor Peirce the opportunity, by a few striking lectures in Boston, to arouse an interest which led to the foundation of the observatory at Cambridge; and, by his discussions of the orbit with Sears C. Walker, he and that remarkable computer were brought to mutual acquaintance, and prepared for the still more important services to astronomy which they rendered after the discovery of Neptune. This planet was discovered in September, 1846, in

consequence of the request of Leverrier to Galle that he should search the zodiac, in the neighborhood of longitude 325,° for a theoretical cause of certain perturbations of Uranus. But Peirce showed that the discovery was a happy accident; not that Leverrier's calculations had not been exact, and wonderfully laborious, and deserving of the highest honor; but because there were, in fact, two very different solutions of the perturbations of Uranus possible: Leverrier had correctly calculated one, but the actual planet in the sky solved the other; and the actual planet and Leverrier's ideal one lay in the same direction from the earth only in 1846. Peirce's labors upon this problem, while showing him to be the peer of any astronomer, were in no way directed against Leverrier's fame as a mathematician; on the contrary, he testified in the strongest manner that he had examined and verified Leverrier's labors sufficiently to establish their marvelous accuracy and minuteness, as well as their herculean amount.

"A few years later, 1851 to 1855, Peirce published the remarkable results of his labors upon Saturn's rings. Professor G. P. Bond had seen the ring divide itself and reunite, and had thereby been led to show by computation from Laplace's formulæ that the ring could not be solid. Upon this Peirce investigated the problem anew, and showed that the ring, if fluid, could not be sustained by the planet; that satellites could not sustain a solid ring, but that sufficiently large and numerous satellites could sustain a fluid ring, and that the actual satellites of Saturn are sufficient.

"In 1849 he was appointed consulting astronomer to the 'American Ephemeris and Nautical Almanac,' and rendered efficient service in bringing that publication to its condition of honorable authority, particularly in the lunar tables which he furnished, in his treatment of Neptune, and various methods of computation. He also assisted Professor Bache in the Coast Survey, and was, for many years, of great service in that important national work before he was himself appointed superintendent in 1867. His calculations of the occultations of the Pleiades were very laborious and exact, and furnished an accurate means of studying the form, both of the earth and her satellite. His criterion for rejecting doubtful observations is an ingenious and valuable extension of the law of probabilities to its own correction. His detection of the mental error of lurking personal preferences for individual digits is a curious specimen of that acuteness of observation which characterizes his own mind.

"He held the office of Superintendent of the Coast Survey from 1867 to 1874. Coming after such able men as Hassler and Bache, to an office which required not only familiarity with mathematics and physics, but also great knowledge of men and executive ability, he was not found wanting, but showed that the theory of the Stoics will sometimes hold good to-day—the really great man shows himself great by any and every standard. The Coast Survey has, since the year 1845,

steadily advanced in public favor, and its work commands the highest respect among all men competent to judge throughout the world, as being not only of direct service to the nation, but as making constant valuable additions to science.

"Many monographs, bearing the marks of Peirce's individuality and peculiar power, have been read by him before various academies, societies, and institutions; but only the results of most of them have ever been furnished for publication. Among these may be mentioned an investigation of the forms of stable equilibrium for a fluid in an extensible sack floating in another fluid, being an *a priori* embryology. Also, the motions of a billiard-ball, an instance in nature of discontinuity, when the ball leaves its curve, and goes on a tangent; another, the motion of a sling, curious from the immense variety of forms comprised under exceedingly simple uniform conditions.

"In 1857 he published a volume, summing up the most valuable and most brilliant results of analytical mechanics, interspersing them with original results of his own labor. A year or two later an American student in Germany asked one of the most eminent professors there, what books he would recommend on analytical mechanics: the answer was instantaneous, 'There is nothing fresher and nothing more valuable than your own Peirce's recent quarto.' In this volume occurs a singular instance of a characteristic which I have already mentioned. Peirce assumes as self-evident that a line which is wholly contained upon a limited surface, but which has neither beginning nor end on that surface, must be a curve reëntering upon itself. By means of this hyper-Euclidean axiom he reduces a demonstration, which would otherwise occupy half a dozen pages, to a dozen lines.

"In 1870, through the 'labors of love' of persons engaged on the Coast Survey, an edition of a hundred lithographed copies was published, of certain communications to the National Academy upon 'Linear Associative Algebra.' In 1852 Hamilton, of Dublin, had published his wonderful volume on quaternions; and this had been followed by various other attempts to create an algebra more useful in geometrical and physical research than the coördinates of Descartes. Ordinary algebra deals only with quantitative relations, and the object of the arithmetic of lines and of Cartesian coördinates had been to reduce distances and directions to a comparison of quantity. But Hamilton introduced quality also; and his algebra employed the dimensions of space, unchanged and essentially diverse, in computation. His imitators and followers had not succeeded in improving or in really adding to his methods. But Peirce, in these communications to the Academy, attacks the problem, according to his wont, with astonishing breadth of view and boldness of plan. He begins with a definition of mathematics, shows the variety of processes included in his definition, passes then to its symbols, shows the nature of qualitative and of quantitative algebras, and of those which combine the two,

and says he will investigate the general subject of algebra. First, he limits himself in this volume to algebras handling less than seven distinct qualities—that is, not exceeding six. The notation is then discussed, and the necessary enlargements and modifications of the algebraic signs and symbols are clearly defined. The distributive and associative principles in multiplication are adopted; but not the commutative; and he confines himself to linear algebras — that is, to those in which every expression is reducible to an algebraic sum of terms each expressive of a single quality. After a full discussion of the general results which must be found in all algebras under these conditions, he begins with single algebras, then double, then triple, and so on up to sextuple, making nearly a hundred algebras which he shows to be possible, and of which he gives the great features. There are almost no comments upon them; and it is only by a patient examination for himself that the reader discovers that, of all these numerous algebras, only three have ever been heard of before. First, of the two single algebras we have one, which is the common algebra, including its simpler form of arithmetic. Secondly, of the three double algebras, we have one, viz., the calculus of Leibnitz and Newton. Thirdly, of over twenty quadruple algebras, only one has been used, the quaternions of Hamilton. Such is a brief abstract of this book of marvelous prophecy. The most noteworthy things which he has done since its publication are a course of Lowell lectures, given about a year ago, on 'Ideality in Science,' and a series of communications to the American Academy, which, it is understood, is still to be continued. In the Lowell lectures he embodies many of his views on philosophy and religion which are peculiarly dear to him, and are always listened to with profound interest, even by those of less religious nature. In the communications to the Academy he is discussing, with all his wonted power, questions of cosmical physics, and particularly theories concerning the source and supply of the sun's heat.

"While Professor Peirce has the tenacity of grasp and power of endurance which enable him to make the most intricate and tedious numerical computations, he is still more distinguished by intensity and fervor of action in every part of his nature, an enthusiasm for whatever is noble and beautiful in the world or in art, in fiction or real life; an exalted moral strength and purity; a glowing imagination which soars into the seventh heavens; an insight and a keenness of external observation which make the atom as grand to him as a planet; a depth of reverence which exalts him while he abases himself."

CORRESPONDENCE.

ABOUT ANTS.

Messrs. Editors.

About four years ago a large, wholesale-grocery firm, doing business on Strand Street, in this city, received a consignment of several barrels of *onions*. These onions were raised by a German farmer living in one of the counties lying west of the Colorado River, and near the line of the railroad running between Galveston and San Antonio. The onions were grown in a black, sticky soil, as shown by the large quantity adhering to them. In some of the barrels there were a great number of small *black* ants, which were evidently brought here with the onions from the same place. This particular species of ant was unknown here before. The Island of Galveston is mostly sandy, and the ants heretofore observed here were of light color. These imported colonies have increased enormously, until there is not a counting-room on Strand Street that is not literally *infested* with them. I am no entomologist, but it seems to me they exhibit some peculiarities that would greatly interest Sir John Lubbock. They do not appear to be very troublesome to the grocerymen—not attacking sugar, cheese, etc., which other small ants delight in—but, like a great many people, they show the most decided fondness for *printer's ink* on a newly-printed newspaper. If the morning paper is laid down in the counting room on a chair, table, or desk, in a few moments it will be covered by countless thousands of these lively little pests. They seem to extract something from the ink on the paper of which they are excessively fond. The paper itself they do not injure, and it is only a freshly-printed paper that attracts them. They are very active in their pursuit of fresh newspapers, the moment one is thrown down being the signal for hosts of them to rush from the floors and walls to cover it. They do not seem inclined to be quarrelsome with themselves or their "two-footed rivals," unless disturbed in their favorite pastime, by having the morning paper taken away from them, when, in attempting to shake them off, they frequently inflict some punishment on the hands, thus showing that they are not without the means of defensive and offensive warfare. The book-keepers and clerks have discovered that a *broad chalk-line* drawn around the desk-legs, and repeated daily, will offer an effectual barrier to their ascent of the desk. This is the only preventive yet discovered.

One remarkable fact I desire to call attention to is this: While they have no fondness for the common black writing-ink that does not copy, they are exceedingly fond of a variety of *copying* writing-ink—such as I am using in this letter—made in Paris, and called "Encre violette noire communicative." When the legs of my desk have not been properly *chalked*, and I am writing letters to correspondents, these little pests will cover my paper, run over the fresh writing, and frequently drag the ink on their legs, "making some marks" of their own. (You can see the peculiar chirography of one of my little friends on the first page of this letter.) Sometimes one or more will run up the pen-point as it is moving over the paper, and then occurs a very singular phenomenon indeed: The movement of the pen seems to enrage it, and it immediately plunges its forceps into the thick ink, when at once the ink, which was a dark-violet color, changes to a bright *litmus* color, and seems to have acquired the property of "*striking through*" the paper, no matter if of extra thickness. This change of color I attribute to the *formic* acid the insect discharges into the ink in its rage. In about five minutes the writing changes to a dark-violet again, due, I suppose, either to the absorption of oxygen, the evaporation of the formic acid, or some other chemical change. I may send you some more items of interest about these little pests, but in the mean time I would be glad to know how to be rid of them entirely.

Very respectfully yours,

L. C. Fisher.

Galveston, Texas, *October* 11, 1880.

A BRILLIANT METEOR.

Messrs. Editors.

On the evening of Wednesday, the 9th instant, I observed a very brilliant meteor, which made its appearance in the southwest, at an elevation of about forty degrees above the horizon. Its rate of motion was very slow, and it was visible fully three quarters of a minute. A long bright line was left in its path, and this remained visible from 5.27 o'clock, when I first observed the meteor, until 5.45 o'clock. This streak seemed to be composed of luminous vapor. About five minutes after its appearance, the line took a zigzag form and resembled a "streak" of lightning. Its form was

constantly changing until it disappeared in the approaching darkness. I have never before observed a meteor whose "tail" remained visible so long. The appearance of this meteor created great consternation among the negroes, and many of them imagined that the "last day" had arrived. Nothing has ever been seen to equal it by any one in this neighborhood.

Yours respectfully,
JOHN HAWKINS.

PROSPERITY, S. C., *December* 10, 1880.

EDITOR'S TABLE.

EVOLUTION AND ORIGINALITY IN ART.

WHEN we compare pictures of the sixteenth and of the nineteenth centuries at the Metropolitan Museum of Art, New York, we are conscious that the charm of modern work is in the truthful delineation of scenery and character, in a certain reflection of our experiences, and in fitness as related to the drift of our imagination. We see a reality and daylight effect which we miss in allegorical and other subjects by artists of the fifteenth and sixteenth centuries. The coloring in pictures by Rubens and Murillo may be impressive, but not even this can obscure the truth that the result is not suited to the modern eye and taste. Most of us prefer nature mirrored by some of our modern masters. In fact, the disposition to appreciate work that seems practical does not favor the introduction of ancient methods. The pursuit of a highly developed sense of humor must impress artists with the importance of close attention to propriety and probability in every design. The fact that ancient art is not suited to present standards of taste was hinted at by Thackeray in "The Newcomes," in the artist who painted immense figures, and whose ideas of art were expressed in a picture fourteen feet high. The novelist intimates that this was high art in a literal sense; but the principal force of his satire is shown in the following remarks from the artist: "The models of the hancient Britons in that pictur' alone cost me thirty pound. . . . You recognize Boadishia, colonel, with the Roman 'elmet, cuirass, and javeling of the period—all studied from the hantique, sir, the glorious hantique."

We also find a ludicrous contrast when ancient art is subjected to the practical test of modern scientific criticism, as seen in the disregard of the laws of equilibrium when angels are represented with arms as well as wings.*

The phrase "school of art" seems objectionable when it means more than a preparatory course by which the rudiments are mastered. An artist ought to be independent of all schools, or have a touch of all in his work, because otherwise his liberty will be restricted.

The advantage of originality appears in strong relief when we examine the negative work of imitators. While it is seen that artists having genius can produce striking effects, using apparently commonplace subjects, it is yet clear that imitators can not produce the same effects, because they fail to see them in nature. The picture painted by a great artist and the original in nature always produce two distinct and very different impressions upon the observer. Owing to some subtile change, which it is impossible for an imitator to follow, the picture has an indefinable effect of which we are not conscious in the natural occurrence or object. For this reason the imitators of original work must always fail. They see the effect after it has been rendered, but they can not perceive similar effects in the outer world of nature, as distinguished from the

* See "Popular Science Monthly," April, 1879: "The Monstrous in Art," by Samuel Kneeland, M.D.

inner world of constructive thought. The striking peculiarity of the work causes them to overlook the delicate and truthful touches by which the general harmony and fitness are maintained. The unprecedented qualities in a work of genius are always sustained by a certain truth to nature.

Originality generally causes severe criticism from contemporary artists, because its tendency is to displace or weaken the established standards. In fact, the opposition usually becomes so intense that the merit of the old method is overlooked on one side, and the great value of a new insight is overlooked on the other. Conservative critics have very often tried to check venturesome innovators by misusing the word mannerism, which does not properly apply to peculiar work. The word means tasteless uniformity. This can be fairly maintained in opposition to critics who think that any incessantly-recurring effect, even though original and striking, is mannerism. Such critical objections ought not to influence an artist to abandon a forcible system of treatment, because the danger of anything really powerful dwindling into a series of tedious repetitions is very slight.

Where there is merit there is continuous growth, whereby the strong current of individuality or sameness of treatment is accompanied by constant transformations, absorbing new material, and finding new methods of expression.

It seems obvious that, after suitable instruction, during which any school may have sway, the artist must look for natural effects in the world directly around him, and not in Rome or in Paris. Nor should he use the special colors or tones advocated by conformists. Objects appear to him of a certain hue, or a certain action of the human figure appears worth rendering. Let him delineate these as he sees them, and be not discouraged by many failures and defects. His strong point may be discerned by close attention to his natural tendencies. In this way the true representation of his impressions will make others conscious of something which before lacked emphasis. Such development of originality in art, accompanied by hard and conscientious labor, may result in works of great fame, and in the evolution of art to a higher grade of adaptation to nature. In the future, the artist may better express ideal conceptions, because a wider mastery of facts and subjects involves increased power and skill.

LITERARY NOTICES.

INTERNATIONAL SCIENTIFIC SERIES, NO. XXX.

Animal Life as affected by the Natural Conditions of Existence. By Carl Semper, Professor of the University of Würtzburg. With Two Maps and One Hundred and Six Woodcuts. New York: D. Appleton & Co. Pp. 472

We have here a volume that will raise still further the already high character of the series to which it belongs. It is a fresh and original contribution to a most interesting branch of zoölogy, which will be indispensable to every naturalist, and will be prized by all readers who care for the progress of knowledge concerning the general phenomena of life. Professor Semper is a leading German biologist, and, being a master of English, he was invited to come to Boston and give a course of twelve lectures before the Lowell Institute. He availed himself of the occasion to bring forward, in a form as popular as the nature of the materials allows, the results of his studies in a special province, zoölogical science.

The author is, of course, an evolutionist, and recognizes that Darwin's views have revolutionized biological method. But he thinks one of the results has been to give too great an impulse to speculation. He says that enough has been done by Darwinists in the way of philosophizing, and that the task now before us is to apply the test of exact investigation to the hypotheses

laid down. It is infinitely easy to form a fanciful idea as to how this or that fact may be hypothetically explained, and very little trouble is needed to imagine some process by which hypothetical fundamental causes, equally fanciful, may have led to the result which has been actually observed. But, when we try to prove by experiment that this imaginary process of development is indeed the true and inevitable one, much time and laborious research are indispensable. We have here the clew to Semper's position as a biologist. He thinks that the school of speculative system-makers, represented by Haeckel, are given to an over-indulgence in hypotheses, and might better concentrate their efforts upon the work of observation and experiment, and the more rigorous investigation of facts.

Of the problems brought into prominence by the doctrine of evolution, none is more fundamental than that of variability in animal organisms. It has, of course, long been known that animals possess this property, but the critical and unsettled question is, To what extent and under what conditions is it manifested? Variability is probably that trait of animate beings which may be first and most easily traced by exact investigation, both to its limits and to its efficient causes. There is, however, at present much strife of opinion upon the subject, and this can be only harmonized by closer research. The present volume is devoted to this inquiry. It is a study in organic variation, and the author aims to present the general facts and hypotheses, which are either of universal significance or offer favorable subjects for experimental treatment.

But it is desirable to still further illustrate the specialty of Dr. Semper's work. The general science of zoölogy has two great branches, morphology and physiology, which, although closely connected, are yet so widely different, both as to their details and to the paths they have struck out for solving their respective problems, that it becomes necessary to keep them separate as two independent divisions of science. Morphology, or the science of form and structure, aims to discover those affinities of relationship in animals which actually exist, and to found on them a natural system of the animal kingdom. It is a statical inquiry—that is, it delineates the conditions and relationships of organic structures, their differences and similarities, simply as existing facts, with no necessary reference to the manner in which they have been produced. Were all life suddenly destroyed upon the earth, and nothing left but dead organisms capable of dissection, there would still remain the material for morphological study.

Physiology, on the other hand, deals with the dynamics of life. It investigates the functions or activities of living parts, and elucidates the forces, causes, and conditions that have produced existing forms. Physiology explains what morphology describes; and, in this large sense, it is the task of physiology to give account of the facts which morphology embraces in its natural system.

But, from this point of view, physiology itself has two broad divisions. Simple physiology, as it is usually known, treats of the activities or the functions of the organs, such as the brain, stomach, heart, muscles, spinal cord, lungs, kidneys, etc., which may be considered as carrying on independent processes, or in their vitally coördinated, intimate, mutual relations. But, in contradistinction to this conception of the physiology of organs, there is also a more comprehensive physiology of animal organisms, which may be properly termed universal physiology. It treats of the general causes, conditions, and laws of the development of organisms, and of the transmutation of one form into others. Here we meet the question of the relation of organisms to their environing conditions, and of animals as acted upon and modified by the external forces of nature. The problem of the geographical distribution of animals, of their extension into new habitats, of their extermination, the acquirement of divergent traits and new qualities, and of the origin of species, is here presented. We have a new order of dependences, analogous to the mutual dependence of organs in common physiology, but it is now a dependence upon the conditions of external nature. Professor Semper says: "If the American prairies were to cease to produce grass, the first result would be the rapid and utter extinction of the now numerous herds of buffaloes, and

on their existence depends that of the surviving remnant of the ancient Indian population of America. If the various insectivorous birds of North America were exterminated, within a very few years, beyond a doubt, all the produce of the rich agricultural districts of that continent would be destroyed. If we change the mode of life of any single animal, the change will instantly have an influence on all the other animals whose healthy existence was in any way dependent on its normal functions before it was altered. Although it is certainly true that the various animals inhabiting a country are not so intimately interdependent as the organs of the individual, the relations in the two cases may be very directly compared. The normal numerical proportion, mode of life, and distribution of animals would be altered or destroyed by the extermination of one single animal, just as the whole body suffers, with all its organs, if only one of them is destroyed or injured. And, in both cases, Nature has analogous remedies at her command. In the one case, the function of the incapacitated organ can be assumed, at any rate to a certain extent, by some other uninjured organ, exactly as, in the other case, the function of the exterminated animal may be fulfilled, with regard to the whole fauna of the country, by some other animal. But a perfect compensation for the loss sustained is impossible in either case."

In further illustration of this idea, Professor Semper says: "The fauna of a district thus takes the aspect of a vast organism whose separate members—the different species of animals—are living parts of the body, and which has had too its embryology—i. e., its development in time. These species as regards the laws of their local distribution may be regarded *morphologically* as the limbs of a gigantic organism which throws one or other of them up into the air on the top of some mountain-peak, while others are flung into ocean-depths, subterranean caves, lakes, or rivers. But they may also be studied *physiologically*, and compared to organs which by their functions and importance influence the life of the whole mass, and are interdependent by the most various physiological relations like the organs of a healthy living body." The nature of the task undertaken by the author is still further exemplified in the following passages:

Before going on to the particular inquiry, it seems desirable that the expression "external conditions of existence" should be as accurately defined as may be. I have already said that I wish to see as wide an application given to it as possible, so as to include every influence, however insignificant and difficult to detect, that can affect the "fitness for survival" of a species, and to investigate its mode of action. This explanation might suffice, but I prefer to illustrate my meaning by a few further considerations.

Everything which tends to hinder or to favor the continuance of the life of the individual and the propagation of the species, as such, must be regarded as a condition of existence for that species. In this sense every organism existing on the face of the globe, as well as every inorganic constituent of the earth's surface and of the atmosphere, is a condition of existence for all animals. Their relations to those organic and inorganic elements differ only in degree, in being more or less remote. Heat or cold, light as well as nourishment, the density of the atmosphere, the water or the soil in or on which animals pass their lives, electricity, and the chemical constituents of the media surrounding them, whether air or water, the plants or other animals with which they live, either in the closest connection or in mere association—everything, in short—may and must exercise a certain influence on animals, and may be harmful or prejudicial to them; and there is nothing on the face of the earth that may not be regarded as an essential condition of existence to some species of animal. It is self-evident that the influences of these manifold conditions must be in the highest degree various. One animal requires a high temperature in order to live, another a low one; one form prefers a very damp atmosphere, another a dry one; many are destined to live always under water or in the soil, while quite as many disport themselves in the freer medium of the air. If we could suddenly reverse all the conditions of existence which are indicated by these modes of life, we should annihilate all the animal life on the earth; for no fish can swim in the air, no bird can live permanently under water, a mole can not climb, a salamander can not exist in a desert, nor a desert-snail in the virgin forests of the tropics. If, on the contrary, we reverse the conditions slowly, but still at a perceptible rate, it is probable that most animals would perish while a few would survive. But, if we suppose that such changes—in the atmosphere, for instance, in the constituents of water or of the soil, etc.—were effected so slowly as to be perfectly inappreciable by man, it is highly probable that the number of surviving forms would be very considerable. The influence of the conditions of existence thus changed is sometimes very different on nearly allied forms; for instance, one species of *Neritina* can live equally well in fresh, brackish, and sea water, while others

occur only in one or the other, and can not survive any diminution or increase of the saltness of the water they live in. The simple reason of this phenomenon is the fact that the life of an animal depends not merely on the influence of the external conditions, but on the reaction of its own organization. If we transfer a stickleback directly from fresh to salt water, and leave it there for days or weeks, it will not perish if it be supplied with sufficient food. But, if at the same time we place one of the common fresh-water mussels in sea-water, it will soon die, sometimes in a few hours. The remarkable difference in the behavior of these two creatures is easily explained by the following hypothesis: In both animals the salt water is transmitted through the skin to the tissues of the body; but this takes place to a much greater extent in the mussel than in the fish, and thus injures it, while the fish can bear the same quantity of salt it has absorbed. If our migratory fishes, as the salmon, had as great an affinity for the salt of the sea-water as the mussels have, they would soon cease to exist, or would have to become adapted to live wholly in fresh water. Thus every change in the conditions of existence influences different animals in different ways. The problem, then, is to investigate more accurately these different effects of changed conditions.

Professor Semper's twelve lectures before the Lowell Institute form the twelve chapters of his book. The considerations here presented are put forward in the first or introductory chapter, in which he defines his point of view, and the plan of the discussion. The work is divided into two parts, the first being devoted to "The Influence of Inanimate Surroundings," and the second to "The Influence of Living Surroundings." Chapter II takes up "The Influence of Food"; III, "The Influence of Light"; IV, "The Influence of Temperature"; V, "The Influence of Stagnant Water"; VI, "The Influence of Still Atmosphere"; VII and VIII, "The Influence of Water in Motion"; IX, "Currents as a means of extending or hindering the Distribution of Species"; X, "A Few Remarks on the Influence of Other Conditions of Existence"; XI, "The Transforming Influence of Living Organisms on Animals"; XII, "The Selective Influence of Living Organisms on Animals." Appended to the volume are sixty pages of valuable notes, followed by a copious alphabetical index.

Annual Report of the Chief of Engineers, United States Army. Pp. 264.

The report describes what was done during the year ending June 30, 1880, and what was needed to be done for the seacoast and lake frontier defenses of the country, and for the improvement of the rivers and harbors of the whole country; and records the progress of the special work and of the surveys assigned to the corps of engineers. Several maps of Pacific States and of the survey of the Mississippi River, and lake charts, have been published, and an outline map of the territory west of the Mississippi River, on a scale of $\frac{1}{2000000}$, is in preparation.

Life and her Children; Glimpses of Animal Life from the Amœba to the Insects. By Arabella B. Buckley. New York: D. Appleton & Co. 1880. Price, $1.50.

After light came life, and with that life there came its two great functions—growth and development. With the simplest as with the most complex forms there is the same eager race to be run, to increase in size, to multiply, and, thus replenishing this earth, to die. "Life and her Children" is a praiseworthy and admirable attempt to tell us something of the Children that Life sends forth, and of their history. Its main object is to acquaint young people with the structure and habits of the lower forms of life; but in our deliberate judgment it will do a great deal more. None will read its introductory chapter without advantage, and few will read the volume through without enjoyment. Within its narrow limits of three hundred small pages no candid reader would expect to find all the details that might be wished for, or all the illustrations that might be desired. What constitutes the book's chief charm is the marvelously simple yet quite scientific style which runs through it, the food for thought and future study which it affords, and the truly philosophic glow which lights up its every page. The volume gives a general account of Life's Simplest Children, the Protozoa. The word "slime" does not seem to us quite a happy term by which to designate the living protoplasm of these creatures; this word conveys the idea of a something adhesive or glutinous, or of a something thrown off a living organism—a something without a structure (sordies, eluvies)—and there seems somewhat of a "contempt for nature," a thought certainly never present in the au-

thor's mind, in the use of such a word. Jelly would seem a more appropriate word, as conveying the idea of the consistency requisite for life, and would have the sanction of use. Thus the Noctilucæ, called in this volume "tiny bags of slime," were described, if we mistake not, by their discoverer as "tiny spherical gelatinous bodies," and Professor Huxley says, "Noctiluca may be described as 'a gelatinous transparent body about the one sixtieth of an inch in diameter.'"

The chapter on "How Starfish walk and Sea-Urchins grow" is excellent. The story of how the five curious little oval jelly bodies, swimming about by their jelly lashes in the depths of the smooth water in some English bay ended in becoming respectively a lily-star, a brittle-star, a starfish, a sea-urchin, and a sea-cucumber, is well told, and woodcuts, though they make one see as in a glass darkly, help in their own way to make the meaning plain. In the "Outcasts of Animal Life" a difficult problem is treated of. It need not surprise one that it is not solved. The last four chapters tell of "the Snare-Weavers and their Hunting Relations (spiders)"; the insects which change their coats but not their bodies, and those which remodel their bodies within cover of their coats; "the Intelligent Insects with Helpless Children, as illustrated by the Ants." This volume thus tells of the greater part of the living invertebrate animals as they are spread over the earth to fight the battle of life. "Though in many places the battle is fierce and each one must fight remorselessly for himself and his little ones, yet the struggle consists chiefly in all the members of the various brigades doing their work in life to the best of their power, so that all while they live may lead a healthy, active existence. The little bird is fighting his battle when he builds his nest and seeks food for his mate and his little ones; and though in doing this he must kill the worm, and may perhaps by and by fall a victim himself to the hungry hawk, yet the worm heeds nothing of its danger till its life comes to an end; and the bird trills his merry song after his breakfast, and enjoys his life without thinking of perils to come. So Life sends her Children forth; and it remains for us to learn something of their history. If we could but know it all, and the thousands of different ways in which the beings around us struggle and live, we should be overwhelmed with wonder. Even as it is, we may perhaps hope to gain such a glimpse of the labors of this great multitude as may lead us to wish to fight our own battle bravely and to work and strive and bear patiently, if only that we may be worthy to stand at the head of the vast family of Life's Children."

The work forms a charming introduction to the study of zoölogy—the science of living things—which we trust will find its way into many hands.—*Nature.*

Transcendental Physics: An Account of Experimental Investigations from the Scientific Treatises of Johann Carl Friedrich Zöllner, Professor of Physical Astronomy at the University of Leipsic. Translated from the German, with a Preface and Appendices, by Charles Carleton Massey. With Illustrations. Boston: Colby & Rich. Pp. 217. Price, $1.50.

There was considerable excitement a year or two since over the spiritualistic demonstrations at Leipsic, Germany, in which the professors took up the claims of Henry Slade, the eminent American "medium." Zöllner was prominent in the inquiry, and published his results, which arrested attention chiefly from the novelty of some of the doctrines which he connected with the experiments. He published a book of views and results under the title of "Transcendental Physics," which was the third volume of a course of scientific criticism. The substance of that work is reproduced in the present translation, together with numerous well-executed illustrations of the appliances used and the operations performed.

The book is a contribution to spiritualism, and treats of a portion of the experiences of Mr. Slade in his great mission over the world to establish, by slate-manipulations, etc., the immortality of the human soul. Poor old senile Dr. Hare, when captured by the Philadelphia spiritualist several years ago, undertook to prove that the soul is immortal by inventing a wooden spiritoscope for public exhibitions. Believing that this great question has been left in

doubt quite long enough, our enterprising spiritualistic friends have decided that it must be solved. And as speculation seems to have failed to settle it satisfactorily, they are bound to do it in the clearest and completest possible manner by experiment, so that the conclusion shall have the same validity that is conceded to strict scientific investigations. It would seem that Professor Zöllner had got tired of being shut into the common field of natural law as a theatre of research, and was determined to break out and get into a larger and more promising field. Hence he properly terms his new results "Transcendental Physics," that is, physics beyond the sphere of the senses. We doubt if the time has quite come for so ambitious an adventure. Old-fashioned physics is still in its infancy, though its growth is vigorous, its accomplishments already vast, and its legitimate promises boundless. After thousands of years of groping to find the true method of arriving at the truth of nature, that method has at last been found and abundantly verified as opening the right path of future inquiry. Yet the method has been really but just mastered, and we think it would be wise if our physicists could content themselves to pursue it humbly and faithfully for—say the next thousand years. Nor does Professor Zöllner's experience encourage us in the least to qualify this recommendation; for it looks as if he had not yet served half his apprenticeship to the existing and well-attested method. The proneness to indulge in wayward fancies, in groundless conjectures, in imaginary explanations and insane speculations, has always been the great obstacle to sober and cautious science, and we think it is the great office of science to discipline and subdue this tendency. But Professor Zöllner has hardly yet learned the rudiments of his scientific lesson. Nature, as disclosed to the common intellect of man, is not sufficient for him. He scorns its limitations, and is bound to know what is outside. So at the very opening of his book he makes a grand transcendental somersault, and comes down—Heaven save us!—in the fourth dimension of space. Zöllner is free, but we poor worms of the dust can not follow him. We have all we can possibly do in three dimensions of space, and it will be a considerable period before this is exhausted. Let those who are inclined buy the "Transcendental Physics," and follow its author if they can. Yankee enterprise is proverbial, and there will no doubt be many who hold to the inspiring motto of the daring Sam Patch, that "some things can be done as well as others."

Consumption, and how to Prevent it. By Thomas J. Mays, M. D. New York: G. P. Putnam's Sons. 1879. Pp. 89. Price, $1.

This little monograph is aimed at the prevention of the most destructive of all diseases. It offers an explanation of the nature of consumption, and then takes up the various hygienic agencies which are potent to protect the system from its invasion. The author epitomizes his book as follows: "In summing up the considerations in the preceding pages, I think it appears conclusive that consumption, or the tendency to it which exists in many individuals, is essentially a premature dissipation of the force and matter of the body, and that improper food, bad air, deprivation of sunlight, poor clothing, want of physical exercise, disease, imperfect digestion, all accelerate this process of waste. Therefore, in all our efforts at prevention, the path of duty lies straight before us, and consists in conserving these two elements of the body by laying a good foundation in infancy, by preserving the organs of digestion, by eating an abundance of rich and nutritious food, such as fat, butter, meat, milk, eggs, etc., by breathing pure air, by living on dry soil, by wearing warm and comfortable clothing, by taking plenty of physical exercise, and by avoiding disease and injurious occupation."

British Thought and Thinkers: Introductory Studies, Critical, Biographical, and Philosophical. By George S. Morris, A. M., Lecturer on Philosophy in the Johns Hopkins University. Chicago: S. C. Griggs & Co. Pp. 388. Price, $1.75.

This volume is founded on some lectures lately delivered before a mixed audience of ladies and gentlemen at the Johns Hopkins University, Baltimore. It professes to be introductory rather than exhaustive—an invitation to reflective and systematic

study rather than a substitute for it. There is a considerable biographical element in the treatment, and the author's aim seems to be to elaborate "correct views concerning the essential nature and value of the most conspicuous current of abstract thought in the English language." The author is a metaphysician and an ontologist, and, in so far as his work is doctrinal, it is a dry agnosticism. He does not believe that knowledge is bounded by phenomenal relations, and spurns the idea that any amount of generalized truth derived from the sciences can form a system of philosophy properly so called; but, independent of its speculation, there is much instruction to be gained from his work.

Elementary Projection-Drawing. By D. Edward Warren, C. E. New York: John Wiley & Sons. 1880. Pp. 162. Price, $1.50.

Practical Plane Geometry and Projection. 2 vols. By Henry Angel. New York: G. P. Putnam's Sons. 1880. Price, $3.50.

The first of these text-books is the well-known manual of Professor Warren, which has now reached a fifth edition. It has undergone a thorough revision, and some parts of it have been rewritten, while it has been made more complete by the addition of a division devoted to a consideration of the elements of machines.

The work of Professor Angel is one in the "Advanced Science Series" of the publisher, and forms a continuation of the more elementary one of the author in the same series. The chapters upon projection are prefaced by several upon plane geometry, while the main subject is fully presented and illustrated by numerous examples and problems. A volume of finely executed plates accompanies the text.

The subject of projection-drawing, besides being of large educational value, is also of great practical importance. It is concerned with representing upon a plane surface solid objects in such a way as to show their real dimensions, and is, therefore, a necessary preparation for the artisan who has to construct work from drawings of this kind. It is also of value to all those who desire to know how to represent their ideas of any construction, so that they will be understood by mechanics. Any one desiring to pursue the study will find in either of these works all that he needs to a thorough comprehension of it.

The Publishers' Trade-List Annual, 1880. Eighth Year. New York: F. Leypoldt. Price, $1.50.

This massive volume embraces the latest catalogues of their books supplied by the publishers, preceded by an order list including all books issued from January to August, inclusive, by the publishers represented in the annual; a classified summary and alphabetical reference list of books recorded in the "Publishers' Weekly" from July 1, 1879, to June 30, 1880, with additional titles, corrections, changes of price and publisher, etc. (forming a provisional supplement to the American Catalogue); and the American Educational Catalogue for 1880. The work, the materials of which are received directly from the publishers themselves, gives the complete literary history of the year in the United States, and is indispensable to the book-buyer.

The Geology of Hudson County, New Jersey. By Israel C. Russell. (From the Annals of the New York Academy of Sciences.) Pp. 80, with Two Plates.

The geology of this county, which is immediately opposite the lower part of New York City, presents many interesting features, the most prominent of which is the great ridge of trap-rock, forming the southern end of the Palisades, which traverses it from north to south. It is nearly perpendicular on the eastern edge, but slopes back gently toward the west. Beds of triassic sandstone, slate, and shale lie on either side of it. Archæan rocks—gneiss in a part of Jersey City, serpentine at Castle Point, Hoboken—are found within its borders. The top of the trap ridge bears marks of the action of the great glacier, whose moraine is found on Long and Staten Islands and in the "Short Hills" of Plainfield. On the surface are sand-dunes along the Newark meadows and Newark Bay, and on Bergen Neck, and the swamp deposits of the salt meadows, still in process of accumulation. The details of these features, their relations to each other, and their economical and sanitary aspects, are clearly described in the essay.

An Elementary Course of Geometrical Drawing: Containing Problems on the Right Line and Circle, Conic Sections and other Curves; the Projection Section and Intersection of Solids; the Development of Surfaces and Isometric Perspective. By George L. Vose, A. M., Professor of Civil Engineering in Bowdoin College. Illustrated by Thirty-eight Plates. Boston: Lee & Shepard.

This seems to be an excellent introduction to the practice of geometrical drawing. Its method has been used for several years in classes with the most favorable results. It was prepared for the use of the lower classes in engineering schools, but parts of it may no doubt be made excellent use of in the high schools. The author claims that it is well adapted for those who desire to pursue this branch of study by themselves and without a teacher. But he strongly recommends pupils to commence with a master wherever practicable, as they will thus save time, and avoid the formation of bad habits, so easy to get and so hard to lose.

Among Machines. A Description of Various Mechanical Appliances used in the Manufacture of Wood, Metal, and Other Substances. A Book for Boys. Copiously illustrated by the author of "The Young Mechanic." New York: G. P. Putnam's Sons. Pp. 335. Price, $1.75.

On the extensive subject of machinery, which would fill cyclopædias, this volume takes up only such parts as are assumed to have a general interest, and concerning which it is well that all active-minded boys should be instructed. It treats of those fundamental laws which underlie the system of machinery, and upon which are founded the various mechanical combinations which have contributed so much to the development of manufactures. The need of understanding these principles would be apparent, and we remember that hand processes are rapidly disappearing by the substitution of machinery, so that the mechanic who has been trained to a special manipulation hardly knows at what moment an unexpected invention may undermine and destroy his vocation. Each new victory and invention is, moreover, but a step toward others, and we are every day surprised to observe how triumphant ingenuity has overcome difficulties hitherto supposed to be insurmountable, and which makes an inroad upon the traditional handicraft labor, and cheapens a product of general utility. The author of this book, therefore, thinks it a fit time to instruct the younger portion of the community in the details of the more ordinary machines with which they may perhaps some day become closely and personally interested. Twenty chapters are devoted to the most important machines, processes, and mechanical arrangements in the wide field of manufacturing industry.

Telegraphic Determination of Longitudes on the East Coast of South America. By Lieutenant-Commanders F. M. Green, C. H. Davis, and Lieutenant J. A. Norris, U. S. N., in 1878 and 1879. Published by order of Commodore William D. Whiting, U. S. N., Chief of the Bureau of Navigation, Navy Department. Washington: Government Printing-Office. Pp. 87.

The longitude of points on the east coast of South America has been very uncertain until recently, for the results obtained by apparently trustworthy methods have differed by almost incredibly large quantities. The extension of telegraphic cables gave the opportunity to make more accurate determinations from some well-determined point in Europe by way of Madeira and the Cape Verd Islands with the eastern South American coast. The connection was made from Land's End by Carcavellos, at the mouth of the Tagus, and the Brazilian submarine telegraph. The determinations made by the commission, combined with the determinations of meridian distances made by Professor Gould at Cordova, furnish a valuable system of longitudes embracing about twenty stations in the interior. A curious fact connected with this work is, that it has given the first correct determination of the longitude of Lisbon.

The Relations of Science to Modern Life. A Lecture delivered before the New York Academy of Sciences. By Henry C. Potter, D. D. Published by the Academy. New York: G. P. Putnam's Sons. Pp. 29.

The author presents, in the easy, flowing style of a popular lecture, a view of the obligations we are under to science in the commoner features of our domestic and social life.

Learning to Draw; or, the Story of a Young Designer. By Viollet-le-Duc. Translated from the French by Virginia Champion. Illustrated by the Author. New York: G. P. Putnam's Sons. Pp. 324.

This work was the last written by the illustrious French author who has done so much to rationalize art education. His method of instruction was logical, beginning always with the simplest elements and proceeding slowly to more complex considerations, while the progress at every step is made pleasant and attractive. Le-Duc was always suggestive, and, instead of grinding students through a hard didactic course, he ever aims, by showing the connection between one study and another, to make the work intellectually attractive. All special results must have the broadest possible foundation. And in every way the student is inspired with a love of excellence and an ambition to attain the highest standard and accomplish the most thorough work. Of the value of the author's method the translator thus speaks: "Teachers of art, both general and technical, and, for that matter, teachers of any subject, will find this volume of Viollet-le-Duc of no little service in suggesting methods of instruction. It shows how students, young or old, are to be interested; how all the surroundings of daily life contain suggestions for the most interesting and important lines of investigation; how students are to be taught to think out processes for themselves, and to develop their powers of comparison and reasoning; how the study of art of necessity leads us back to the study of nature, which underlies all art; and how, as before said, the basis of all education must be perception, so that learning to draw well and learning to do anything properly depend upon first learning to see correctly."

A Text-Book of Elementary Mechanics. By Edward S. Dana. New York: John Wiley & Sons. 1881. Pp. 291. Price, $1.50.

Professor Dana has aimed in this work to present the subject of mechanics clearly and concisely, and develop its fundamental principles in their logical order. The book is restricted to the mechanics of solids, which is considered under the general heads of kinematics, dynamics, and statics. Numerous problems, involving the principles elucidated in the various sections, are furnished for the pupil to work upon, answers to which are given at the close of the book. We can discover no reason why this latter feature should have been added, and think the space might have been much better devoted to additional problems.

Summary of Substantialism; or, Philosophy of Knowledge. By Jean Story. With Additional Illustrations. Boston: Franklin Press; Rand, Avery & Co. Pp. 113. Price, 35 cents.

The author starts with the assumption that all authority, "so called," not founded on what nature teaches through facts actually demonstrable or knowable through analogy, should be rejected. Nevertheless, he believes that the theory that what is non-objective to the senses is immaterial and unknowable is erroneous and deleterious, as is also the theory that knowledge is, either directly or indirectly, miraculously revealed. In harmony with these doctrines, he endeavors to build up a new philosophy of the human organism. The present essay appears to be introductory to a larger work on the same subject.

The Feeling of Effort. By William James, M. D., Assistant Professor of Physiology in Harvard University. (Anniversary Memoirs of the Boston Society of Natural History.) Boston: Published by the Society. Pp. 32.

The author's purpose is to offer a scheme of the physiology and psychology of volition, to inquire of what nervous processes the feelings of active energy are concomitants. He first considers muscular exertion as an afferent feeling, then examines into the power of the will over exertion, analyzing the cases of acts in which no effort of either is required, in which the stress of effort is laid on the exertion while the will is lightly taxed, on the will when the muscular exertion required is insignificant, and cases in which the will effort operates in all its vigor while the muscular function is not regarded. Lastly, he considers the question of a dynamic connection between the inner and outer worlds, answering it in the negative.

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Address in Medical Jurisprudence. Psychology, State Medicine, etc. By James F. Hibberd, M.D. Philadelphia. 1880. Pp. 17.

On the Action of Carbolic Acid upon Ciliated Cells and White-Blood Cells. By T. Mitchell Prudden, M.D. January, 1881. Pp. 17.

How to Live in Winter. By Amelia Lewis. New York: Food and Health Publishing Office. 1881. Pp. 84. 25 cents.

"The Chrysanthemum: A Monthly Magazine for Japan and the Far East." Yokohama: Kelley & Co. Vol. I, No. 1. January, 1881. Pp. 36. 25 cents each, or $2 a year.

"Quaker City Gazette: A Weekly Periodical devoted to Science, Literature, and Art." E. Ellsworth Wensley, Editor. Philadelphia: Quaker City Publishing Co. Vol. I, No. 1. January, 1881. Pp. 16. $2 a year.

"The Illustrated Cosmos." Issued Monthly. Everett W. Fish, General Editor. Chicago. Vol. I, No. 1. January, 1881. Pp. 16. 15 cents a copy, $1.50 a year.

Principal Characters of American Jurassic Dinosaurs. By Professor O. C. Marsh. Part IV. Spinal Cord, Pelvis, and Limbs of Stegosaurus, with Three Plates. February, 1881.

On the Microscopic Crystals contained in Plants By W. K. Higby. Pp. 18.

Annual Report of the California State Mineralogist, from June to December, 1880. Sacramento. 1880. Pp. 43.

"The Floral World: A Monthly Journal devoted to Floriculture, Horticulture, etc." D. R. Woods, Editor. New Brighton, Pennsylvania. Vol. I, No. 1. January, 1881. Pp. 24. $1 a year.

"The Religious Evolutionist: A Monthly Magazine devoted to a Scientific and Practical Religion." S. W. Davis, Editor. Topeka, Kansas. Vol. I, No. 1. January, 1881. Pp. 28. $1.00 a year.

Circulars of Information of the Bureau of Education. No. 4, Rural School Architecture. Illustrated. No. 5, English Rural Schools. Washington: Government Printing-Office. 1880.

The Geology of Central and Western Minnesota: A Preliminary Report. By Warren Upham. St. Paul: The Pioneer Press Co. 1880. Pp. 58.

Historical Sketch of the Erie Natural History Society. Erie, Pennsylvania. 1880. Pp. 28.

The Succession of Glacial Deposits in New England. By Warren Upham. Salem, Massachusetts. 1880. Pp. 14.

Illinois State Laboratory of Natural History at Normal. Bulletin No. 3. Peoria. November, 1880. Pp. 160.

Thirty-fifth Annual Report of the Director of the Astronomical Observatory of Harvard College. By Edward C. Pickering. Cambridge: University Press. 1881. Pp. 17.

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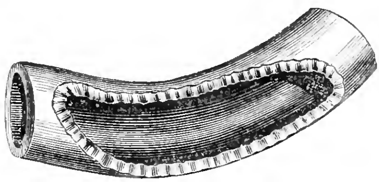
POPULAR MISCELLANY.

Bone-Caves in Pennsylvania.—Professor Leidy in company with Dr. T. C. Porter, of Easton, Pennsylvania, visited, in August last, Hartman's Cave, near Stroudsburg, Pennsylvania, on the invitation of Mr. T. D. Paret, of that place, and examined a number of interesting animal and other remains which were found there. The cave is partly filled with a bed of clay ten feet deep, on which rests a thin layer of stalagmite, and on this about a foot of black, friable earth mingled with animal and vegetable remains. The cave appears to have been too small to be inhabited by the larger carnivora, and no large entire bones of them were found, but about a half-bushel of fragments and splinters of limb-bones of smaller and large animals have been collected, many of which exhibit marks of having been gnawed, whether by rodents or small carnivora Professor Leidy does not assume to decide. Some of the splinters are derived from such large and strong bones that it is questionable whether even the largest carnivora could have produced them, and are presumed to be remnants of human feasts, in which the bones were crushed to obtain the marrow. A few of the bones are somewhat charred, among them a small fragment of a bison's jaw with a molar tooth. Most of the bones are of species still living, but some of them, as jaws of the reindeer, bison, and wood-rat, are of animals no longer belonging to the fauna of the State; and a few, as the teeth of the *Casteroides Ohioensis*,

and the jaws of a young peccary (*Dicotyles nasutus*), are of extinct animals. None of the remains have been identified as positively pertaining to our domestic animals, unless two of the teeth may be those of a fœtal or new-born horse. The vegetal remains include a few small fragments of charcoal and seeds of dogwood, pig-nut, and walnut. Remains of human work were found—a large stone celt of hard brown slate, from the bone-earth some distance within the cave; five bone awls, some of them gnawed; the prong of an antler worked so as to be barbed on one side; a needle of bone resembling a crochet-needle; a fish-hook of bone; and a cone-shell, of a species found on the western coast of Central America, bored through the axis as a head. Professor Leidy has, since exploring this cave, examined a collection of bones in the Museum of the Philadelphia Academy of Natural Sciences, which were found more than thirty years ago in the Durham Cave, Bucks County, Pennsylvania. The bones are of the same character as those of Hartman's Cave.

Temperature of the Breath.—We have before noticed the fact that the effect of breathing upon the bulb of a thermometer through several folds of flannel is to raise the temperature of the thermometer several degrees above that of the mouth and body, and the theory suggested by Dr. Dudgeon to account for the phenomenon, that the breath is the vehicle by which superfluous heat is removed from the body. Dr. William Roberts pronounces this theory untenable, and indicates, as an experiment that will show it to be fallacious, that a naked thermometer placed in the mouth, and breathed upon by expiration, will hardly rise to the normal temperature of that part of the body. He suggests another explanation, which has been accepted by Dr. Dudgeon. It is, that the temperature of the thermometer is raised by the action of the specific heat which is liberated by the condensation of the moisture of the breath. If the experiment of breathing is repeated with the same thermometer and flannel at short intervals, the degree to which the temperature rises decreases with each repetition till at last only a slight effect is produced. This is because the flannel, already charged with moisture, has a diminished capacity for condensing more moisture with every new trial of the experiment. If, on the other hand, the flannel is thoroughly dried before beginning the experiment, an increase of temperature to 115°, or several degrees higher than the highest noted by Dr. Dudgeon, is indicated immediately on breathing upon it. The capacity of the cloth for absorbing moisture has been largely increased by the drying.

Perforation of Lead Pipes by Rats.—We give herewith another well-authenticated case of the perforation of a lead water-pipe by rats, kindly furnished by Mr. Henry C. Hallowell, of Sandy Spring, Maryland. Mr. Hallowell writes: "As the confirmation of a statement is sometimes of value, I send a hasty sketch of a piece of lead pipe in my collection that has been gnawed by rats, as described by Dr. William Eassie, in "The Popular Science Monthly" for January. The pipe is one



Lead Pipe gnawed by Rats.

and one eighth inch in diameter, and the lead three sixteenths of an inch thick. The hole is three inches long, and appears to have been made to get to water."

The Manufacture of Indigo in Bengal.—Indigo is almost entirely obtained from leguminous plants of the genus *Indigofera*, of which two principal species are grown in India and America. The factories in Bengal are provided with filters, presses, a boiler, drying-grounds, reservoirs, and vats for fermentation. The plant is cut in the morning, and taken to the factory. In the evening it is loaded in the vats, tightly pressed down, and then submerged in water and exposed to a process of fermentation for from nine to fourteen hours. The progress of the fermentation is tested by draw-

ing off a little of the liquid, when, if it is of a pale straw-color, the quantity of indigo will not be so great, but the quality will be better than when it is of a deep-yellow tinge. The liquid, when it is drawn off after fermentation, is always of a more or less deep-yellow color. It is allowed to remain for some little time, and is then, while still warm, beaten with long bamboos for two or three hours. It gradually becomes of a pale-green color, and the indigo forms into small flakes. The mass is allowed to remain for half an hour, and the water is then turned off gradually by withdrawing one by one corks which have been placed at different levels in the vat. The water is returned to the river, and the deposit, which resembles a thin scum, is carried through a trough into a deep trench. It is then brought up and boiled for a short time to prevent a second fermentation, which would turn it black and spoil it. After about twenty hours, it is again boiled for three or four hours; then poured off, and strained through a filter. A thick, deep-blue paste, almost black, remains on the cloth of the filter after the liquid has been strained through. This paste is exposed to a pressure, which removes every particle of moisture, after which the indigo is found in a large, thick block, the cutting of which demands extreme care. The blocks are put in the drying-ground, a large brick building from which the light of the sun is carefully excluded, and, after from three to four days, are ready to be sent to the market.

Purification of River-Water by Organic Agents.—Mr. R. Warrington, in "The Chemical News," notices that, in the discussions on the qualities of river-water, the destruction of sewage which takes place in such water is in every case referred to the oxidizing influence of the air, and the action of organic agents is overlooked. Yet it is evident, and generally admitted, that these agents play an important part in the change of organic into inorganic matter. The process is in effect the joint work of a number of independent organisms having different functions, the action of one class following that of another, and each carrying the process through a particular stage. First are the fungi, whose main function is apparently the rapid oxidation of carbon; then come the bacteria, embracing many families of similar physical structure, but endowed with very different chemical powers. One class attacks nitrogenous organic matter and liberates nitrogen in the form of ammonia; another determines the conversion of carbonaceous organic matter into inorganic carbonic and nitric acids. Lastly come the chlorophyl-bearing plants to consume these products of the lower organisms; they also have the property of assimilating urea and inorganic ash constituents. These organisms must follow in their order, or they will fail to do their work. Sewage will finally be destroyed in a river of adequate temperature, unless the natural agents of oxidation are excluded by the addition to the water of chemical refuse fatal to organic life, or unless vegetation is prevented by artificial means. Temperature and light, or rather darkness, are important factors in the process. The experiments show that the oxidation in rivers increases as the temperature rises. The amount of dissolved matter in rivers is found to be greatest in February, when organic action is suspended, and least in September and August, when the action is most energetic.

Mind in Work.—It is set forth on the highest authority that whatever we do should be done with our *might*. This precept being interpreted means that there should be mind in work. The difference between a work of art and the product of machinery lies in the presence of a mark of mind directing the handiwork in the one case, while the other is simply a predetermined result produced by a duly formulated process wherein or whereby physical forces are directed and controlled by other physical forces on a set plan, to perform a defined series of actions, which *must*, in the nature of things, end in the production of the effect foreseen. Mind sets the one process, or series of processes, in operation, and they work out their physical destinies. In the other, mind is the active controlling power throughout. Starting from these premises, we are now concerned to point out that little or no success can be expected in any calling which does not suit the temper and bias of the mind

pursuing it. There can not be "might" or earnestness—of the best sort—in an uncongenial enterprise. It is not necessary that an occupation should be ardently loved, but it is indispensable that there should be some special fitness for a calling if the powers of mind are to be resolutely and effectually engaged. Medical men see a great deal of life, and nothing strikes the observant family practitioner more than the number of feeble, sauntering, and loitering minds with which he is brought into contact. No inconsiderable proportion of the common and some of the special ailments by which the multitude are affected may be traced to the want of vigor in their way of living. The human organism is a piece of physico-mental machinery which can only be successfully worked at a fairly high pressure. It will almost inevitably get out of gear if the propelling force is allowed to fall below a moderately high standard of pressure or tension, and that degree of tension can not be maintained without so much interest as will secure that the mind of the worker shall be in his work. It is curious to observe the way in which particular temperaments and types of mental constitution are, so to say, gifted with special affinities, or predilections for particular classes of work. The men who work in hard material are men of iron will, which is equivalent to saying that the men of what is called hard-headed earnestness find a natural vent for their energy in work that requires and consumes active power. On the other hand, the worker in soft materials is commonly either theoretical or dreamy. There is a special type of mental constitution connected with almost every distinct branch of industry, at least with those branches which have existed long enough to exercise a sufficient amount of influence on successive generations of workers. We are all familiar with what are called the racial types of character. It would be well if some attention could be bestowed on the industrial types, both in relation to educational policy and the study of mental and physical habits in health and disease.—*Lancet.*

Changes on the Moon.—A European astronomer, M. Jules Klein, affirmed, in March, 1878, that he had discovered evidence contradicting the generally received opinion that all action had ceased upon the moon. He claimed that he had observed a large depression, in the shape of a crater, newly formed to the east of the crater Hyginus, and that a large valley had been made south of the mountain called by Mädler the Colimaçon. His views were disputed, and it was said that he had seen, not something that was really new, but something that had been overlooked in previous observations. He defends the accuracy of his affirmation in a recent number of the "Astronomische Nachrichten" by producing evidence that the objects he describes had never been noticed, until he pointed them out, by astronomers who had made a constant study of the moon, and whom they could not have escaped if they had not been new. The original journals of Gruithuisen, which have just been published, bear directly upon the question. They are accompanied by the astronomer's original designs, which are of an astonishing fineness and accuracy. Among the designs is one including the crater Hyginus, with its great cleft, and Mount Colimaçon. The most minute details are given; but the depression in Hyginus is wholly absent, as is also the valley south of Colimaçon, although every other furrow on that side of the mountain, of which Gruithuisen made a special study, is scrupulously given. M. Klein describes his object as a large funnel-shaped crater, from which a shallow ladle-shaped valley extends toward the south, terminating in a small crater. The valley may be recognized, when it is not in shadow, as a gray spot. M. Klein believes, but does not undertake to prove, that nebulous clouds are produced on the moon which have no analogies on the earth; and that whoever examines the observations which have been made on the lunar formations from the time of Gruithuisen to the present will be convinced that changes for which we can not account are taking place on its surface.

The Ocean-Currents of Greenland and Iceland.—Captain N. Hoffmeyer, Director of the Royal Danish Meteorological Institute at Copenhagen, has published a summary of the facts ascertained in the recent deep-sea explorations of the Danish schooner

Fylla, Captain Jacobson, which help to explain why Iceland, lying nearly on the edge of the Arctic Circle, is not frozen like its neighbor Greenland. The first Norwegian Deep-Sea Expedition, under Professor Mohn, brought out the surprising fact that the bank on which the British Islands lie is connected by a submarine ridge, of at most three hundred fathoms below the surface of the water, with the Faroe Islands, and that these islands are similarly connected with the southeast coast of Iceland; further, it was discovered that over this bottom ridge separating the Atlantic water in its great deeps from the water of the Arctic Sea—at least in summer—a relatively warm mass of water was moving toward the northeast which fully prevented the cold bottom water of the Arctic Ocean from flowing into the North Atlantic basin. Since, however, the depths of the Atlantic are occupied with a bed of water only a few degrees above the freezing-point, the cooling of which can not be ascribed to circumstances of place and position, but must be caused by an inflow of polar waters, the fact ascertained by the Norwegian expedition that no such inflow takes place between Iceland and Europe, in the broadest passage between the two seas, has become of the greatest scientific importance. Attention was accordingly directed to the other passages between the two seas—the Denmark Straits between Greenland and Iceland, and Davis's Straits—concerning the features of which not enough was accurately known. The most that had been learned concerning them was the work of a few observers, chiefly Admiral Irminger, who, by comparing the annual reports of voyages between Greenland and Iceland, had found that the Atlantic water along the fifty-ninth parallel, between the Orkney Islands and 30° west, over an extent of about nine hundred nautical miles, had tolerably uniform and relatively high temperature on the surface with a superficial current to the north; that, further, in consequence of this current, the warm surface-water, at least in summer, reached the south coast of Iceland essentially unchanged in temperature, and was directed thence toward the northwest and north into the Denmark Straits and along the west coast of Iceland; that, on the other hand, a cold stream filled with thick drift-ice flowed from the Polar Sea along the east coast of Greenland through the Denmark Straits to Cape Farewell, and was strong enough to reach over to the northwest coast of Iceland and fill its fiords with ice. As an offset to this, the ice does not, even in winter, enter the great bays of the west coast of Iceland, and the fisheries are prosecuted in those waters through the whole year. North of Iceland the stream sets decidedly toward the east, and often brings with it Greenland ice, which blockades the whole coast for a longer or shorter time. Admiral Irminger believes that this stream is a branch of the great East Greenland ice-stream which has rebounded from the northwest coast of Iceland and been deflected to the east. Other investigators have reached conclusions agreeing with these. In order to determine the matters which were in question, the Danish Government, in 1877, provided the Fylla with the necessary apparatus and ordered Captain Jacobson to take soundings and measurements of temperature. He performed his work with much energy, against many difficulties, and discovered that the warm stream which had been mentioned as washing the west coast of Iceland has considerable depth, and that it is strong enough at the North Cape to pass around it in its continued progress along the north coast of the island. The meteorological observations in the Island of Grimsey have also shown that this warm stream affects the island in the same way in the winter and considerably moderates its climate. Nevertheless, in severe winters, the Greenland ice pushes far down and causes the warm current to be covered with its cold meltings; the season is protracted, and Iceland suffers a bad year with hardly any summer.

Stammering.—Stammering, according to M. A. Chervin, generally originates in a sudden nervous shock which the victim of the affection has received in childhood; sometimes it is a habit which has been acquired by the practice of imitating other persons who stammer, or by constant association with stammering members of the family. It takes place whenever the rhythm of respiration is interrupted by the effort to speak being made at the wrong stage of breathing. Speaking, to be easy and regular,

should be an act of expiration. Some persons begin to speak while they are drawing their breath, but are compelled to halt as soon as they have uttered the first syllables. They spit out their syllables; then, suffering an oppression of the chest, are compelled to relieve themselves from it, and the rest of the phrase goes out in a gasp. Others speak during the period of expiration, but do not begin until the lungs have been nearly emptied and have not air enough to keep up the action of their vocal organs. Others speak through their nose and fail in the utterance of the stronger consonants. Stammerers are not always equally liable to suffer from their affliction, but the intermittence is not regulated by any law. Sometimes they may be helped over the difficulty by pronouncing the embarrassing word for them; sometimes by a little diversion of attention. Children who stammer much are often able to speak with perfect freedom under circumstances in which they are free from embarrassment, as the stuttering boy playing with his dog, or the girl with her doll; but, if another interrupt them with the most simple question, they will begin to halt in their speech. The fault may often be alleviated or made to disappear by reading or speaking aloud when alone. Some persons are accustomed to use, before the syllables which give them difficulty, certain words which seem to them to smooth the way of the rebellious consonant. One stammerer is mentioned by M. Chervin who had the habit of saying *et*, *mais*, *oui* (and, but, yes), before every difficult word, whatever it might be, which often gave a ludicrous turn of expression to his remark. The same expedients do not, however, always have the same operation with different persons, and sometimes result oppositely with the same person. Singing is nearly uniform in its action. In chanted or rhythmic speech, as in the recitative of operas, stammering is very rare. Singing, reduced to its most simple element, cadence, enters largely into the application of the means employed by M. Chervin for the cure of the affliction. The poetic cadence in the declamation of verse and the variety of intonations which give to poetic diction a character very different from that of familiar conversation, are generally effective in preventing halting in the speech. More than this, it is often enough to speak or read in the same measure with a stammerer to make it more easy for him to speak or read. The accompaniment serves as a kind of support or guide, which affords incontestable assistance in a majority of cases. Generally, reading and recitation are easier than conversation, especially if they are carried on in a low voice. It is proper to remark, in connection with this point, that with all stammerers whose difficulty is accompanied with glottic spasms, articulation in a low tone, diminishing the play of the vocal chords, operates as a restraint upon one of the provocations to stuttering. There is no resemblance between stammering and what is called writer's cramp, which results from the excessive use of an organ; no connection between it and paralysis. When it occurs with paralysis, it is only as one of the symptoms. In the majority of cases it appears as a single infirmity in subjects otherwise healthy, is generally wholly curable, and may be ameliorated in the most rebellious cases.

Turquoises.—All the turquoises in Europe come from one mine, which is situated in Persia, on the road from Teheran to Herat, not far from Meschid, the capital of Khorassan. Two kinds of turquois are distinguished in mineralogy: the real stone turquois, or calaite (in Persian, *sengui*), and the osseous turquois or odontolite. The latter is considered a false turquois, and is supposed to be composed of a piece of bone colored with phosphate of iron. The Persians again divide the real turquoises into two kinds—the *sengui*, or stony, and the *khaki*, or earthy, turquois—accordingly as they are incrusted with the rock, or are obtained by washing the earth, and are clear of foreign matters. The mines are at the village of Maden, in the region of the salt-mines of Doulet Aly. The salt district is like an immense block of salt just covered with a thin soil of red clay. The miners get out the salt by making a hole, putting a ball of clay into it, and striking upon the clay till a block is detached. The hills in which the turquoises are found have the same reddish-gray aspect as is remarked in the salt-rocks; they are formed of rocks and an earth full of pebbles, and are bored in their whole extent with galleries, tunnels, abandoned pits,

and land-slides, which give the place a curious aspect. The mines belong to the Government, as do also the salt-mines, and are farmed out for a small sum. They are not very actively worked, and the product is small. The process for extracting the gems is much like that pursued in mining for the salt, except that, instead of using a ball of clay, the miners burn a bunch of dry grass in the hole, taking precaution, as soon as the cracks appear, not to damage the turquoises which may be incased in the block. The stones are generally found in groups, often numbering twenty-five or thirty, incrusted with a thin calcareous envelope which is white next to the mineral, brown on the side next to the rock. The *khaki*, or earthy turquoises, are found in the valley adjoining the hills, in a soil composed of gravel and rounded stones resting on a clay subsoil. After the earth has passed through two or three washings, a considerable number of turquoises are left, of moderate size, but pale and of little value, if the diggings are fresh. The turquoises in the older pits have a better color, because, the miners say, the stones acquire their color with age. Among the largest turquoises which have been mentioned are one of which a drinking-cup was made for the Shah of Persia, and one in which the treasure of Venice was kept, and which weighed several pounds. Generally the large turquoises are pale or discolored, and of little value, and are used principally for the decoration of furniture, and of the saddles and bridles of rich Persians.

Heat in Tunnel-Excavations.—Dr. F. M. Stapff, engineering geologist of the St. Gothard Tunnel, has published, in the "Revue Universelle des Mines," the results of the studies he made during the progress of the operations in the tunnel as to the highest temperature at which men can work underground, and the depth below the surface at which that temperature is likely to be met in tunneling. The limit of temperature at which men can work depends upon the length of their exposure, the amount of exertion they put forth, their condition, and the nature of the atmosphere, particularly as to its degree of moisture. It is certain that men can not become used to stand, for any length of time, a higher degree of temperature than from 140° to 165° Fahr., even when they keep perfectly still, and are in quite pure air. Men have worked at 104° on railways in the United States and Mexico, at 72° to 94° in Belgian collieries, at 125°, under exceptionally favorable conditions, in the Fahlun copper-mine in Sweden, and are said to work occasionally in the stoke-holes of tropical steamers at 156°. The highest temperature observed in the Mont Cenis Tunnel was 86°. In the St. Gothard Tunnel work was carried on at 87° on the Airolo side, in an atmosphere saturated with moisture, and at 84° on the Göschenen side, in an atmosphere less highly impregnated. Professor Du Bois-Reymond estimates that men can stand a temperature of 122° when the air is as dry as possible, but that even 104° is likely to be fatal in an atmosphere saturated with moisture; and he recommends quick lime, notwithstanding the heat it gives off, as preferable for counteracting the heat, because it absorbs the moisture, to ice, which adds to it. Salt and ice are, however, good. The highest limit of air-temperature theoretically possible in tunnel-work would be that which would induce fever-heat, or 107° in the body; the highest practicable, but still a dangerous, temperature should not raise the heat of the body over 104°. On this basis an extreme temperature of 114° would be admissible at the Göschenen end, and of 100° at the Airolo end, of the St. Gothard Tunnel. The temperature within the borings of the St. Gothard Tunnel was found to increase with the depth of the excavation, at a general average rate of 1° Fahr. per 88·1 feet of vertical depth below the surface of the mountain. The rate is subject to local variations, giving sometimes as much as 9° of error, arising from irregularities in the surface of the mountain. Thus the actual temperature is higher than the calculated temperature under depressions of the surface, and lower under peaks; but for considerable lengths of tunnel the calculated and actual temperatures substantially agree. Dr. Stapff estimated, when the excavations at St. Gothard had been driven to within about one thousand yards of the middle of the tunnel, that the temperature at the middle, before piercing the wall between the two excavations, would be 89° for the rock, and the same for

the air about one hundred and fifty yards behind either fore-breast. The actual temperatures in March, 1880, after the two excavations had been connected, were 87°. The temperature of the air immediately at the two fore-breasts was brought down to 82° Fahr., while boring, and to 86° Fahr. while clearing away the *débris*, or to about 5° below the calculated point, by the operation of an extra supply of compressed air. The question of cooling the air in the tunnel-galleries presents great difficulties, for the heat of the rocks is inexhaustible, and the air, no matter in what condition it may be delivered, becomes heated up again nearly as soon as it is distributed. The use of jets of water is objectionable on account of the increase of dampness that attends it, and the mists to which it gives rise. Dr. Stapff is not able to recommend any better cooling apparatus than a combination of the cooling mixture of ice and salt and quicklime.

Relation of Elevation and Exposure to Rainfall.—M. Th. Moureaux has drawn up a set of maps based upon the reports of the Central Meteorological Bureau of France, which show what was the distribution of rain over the country for each month of the year, and for the whole year, 1878. Except in February and September, which were dry, the year was a moist one; the rains were excessive, except in the Mediterranean littoral and some parts of the valley of the Saône. The amount of rain increased with the height of the locality. The map shows at the first glance that the low regions, the plains, correspond with the smallest falls. The minima were constant during the whole year; in constructing the monthly maps, the absolute minimum in each month was found to be on the littoral of the Mediterranean, and the relative minima were found to correspond to the large valleys, whatever might be their direction. The valley of the Loire below Orleans, and those of its affluents on the left bank, the basin of Paris, the valleys of the Garonne, of the Saône, of the Lower Rhône, were regions in which relatively little water fell. In mountainous regions, at the same height, the rains were much more abundant on the slope exposed to the direct action of moist winds than on the opposite slope. When a mass of air rose along the side of a mountain, it became steadily cooled, its load of moisture was relatively increased, and the clouds soon precipitated their burden; the condensation was more active as the difference of temperature increased, and as the air of the plain approached the point of saturation. The inverse phenomenon was produced on the opposite slope. Descending the side opposed to the direction of the wind, the air became warmer, and its temperature further and further from its dew-point; the rain was light and often there was none. The minima were thus constant during the several seasons. The same was not the case with the maxima. They could be divided into three groups: 1. Those maxima wholly due to altitude; 2. Those which were attributed to the combined influence of altitude and of the situation as related to moist winds; 3. Those which were connected with the action of neighborhood to the sea. In the first group, the rule was absolute; the highest points constantly received more rain than the surrounding places of a less altitude. But this was not the case with the maxima which were due to the neighborhood of the sea or to exposure to rain-bearing winds. The maxima of the hills of Normandy, Brittany, and Poitou were due to the fact that those provinces lay near and to the east of a great mass of water. This influence was made effective by the frequency of winds from the west, which drove toward those regions the moist air of the ocean; accordingly, it was most clearly manifested during the cold season; but the maxima were considerably lessened, or disappeared when the rains came from the southeast. So the maximum of the gulf of Gascony resulted from the predominance of winds from the west or northwest; and, when the south winds were pouring torrential rains into the basin of the Rhône, but little water fell in the basin of the Adour. Heavy rains did not fall simultaneously over the whole of the central plateau. They were limited to the slopes exposed to the direct action of rain-bearing winds. When brought by winds from the south or southwest, as was most frequently the case, they fell upon the side toward the ocean; while, when they came from the south and southeast, they were deposited on the

Mediterranean slope. The laws of the distribution of rains, which M. Belgrand announced in 1865 for the valley of the Seine, are verified by the maps, and their general application appears to be made more clear every year.

The Asteroids and Jupiter.—Dr. J. Holetschek has published, in the "Deutsche Rundschau," a summary of our present knowledge of the asteroids, or the group of bodies which revolve in orbits between those of Mars and Jupiter. Of the two hundred planets of this group which had been discovered in July, 1879, sixty-three were discovered in the United States, sixty in France, twenty-eight in Germany, seventeen in Austria, fifteen in Great Britain, eleven in Italy, five in Asia, and oue in Denmark. Professor Peters, of the Clinton Observatory, has discovered more (thirty-six) than any other single observer. The orbits of one hundred and seventeen were calculated in Germany, those of forty-eight in the United States, and those of the others in Austria, France, England, Russia, and Sweden. The theory at first adopted that these bodies are the fragments resulting from the explosion of a larger planet, was contradicted by the calculations of Professor Newcomb, in 1860. D'Arrest sought to establish the fact of a connection among them by finding relations in the eccentricities of their orbits, but the elements of the planets discovered since have set this theory at rest. The idea of a collision of two bodies has also been given up. The little planets mock all attempts to combine their relations, and each asserts its individuality as an independent member of the solar system. They exhibit common features only in the limitation of their orbits, so far as the discovery of them has extended, to a particular zone, and in a corresponding limitation of their periods of revolution around the sun. Taking the earth's mean distance from the sun as unity, the halves of the major axes of their orbits may all be represented by numbers between two and four. Their periods of revolution around the sun are between four and eight times that of the earth. Great variations occur within these limits. Very perceptible and peculiar intervals exist in several cases in the mean distances of particular asteroids from the sun, which might once have been accounted for by supposing that there were planets not yet discovered which would occupy them. But as the numerous discoveries of new planets have failed to furnish the bodies sought for, and have rather rendered the gaps more obvious, it has been suggested that the vacancies are not casual, but are owing to a real natural cause. A theory has been suggested that they are occasioned by the attraction of Jupiter, and is supported by the fact that a vacancy exists at every distance from the sun at which the time of a planetary revolution would bear a definite relation to the year of Jupiter. A planet could not continue in such a position, for it would be subjected to disturbances at every conjunction with Jupiter, the effect of which would be to draw it out of its course and out of its relation with the larger planet till it found a new period of revolution not commensurable with that of Jupiter. A large gap exists between the asteroids Gerda and Sibylla, in the place which a planet making two revolutions to one of Jupiter would occupy. Gerda, having an orbit interior to this place, completes its revolutions in fifty-four days less; Sibylla, with an exterior orbit, requires a period one hundred and two days longer than that of half the year of Jupiter. Similar gaps exist at distances where planets, if there were any there, would have periods of revolution corresponding to two thirds, two fifths, three fifths, two sevenths, and three sevenths of that of Jupiter, although planets are found on either side of these spaces whose periods of revolution bear no fractional relation, or an extremely remote one, to that of Jupiter. Saturn also produces modifications in the position of the asteroids which are less noticeable on account of its greater distance and lighter mass.

The Diffusion and Softening of the Electric Light.—M. L. Clémandot, a French engineer, has invented a new arrangement for the diffusion of the electric light, which, he claims, presents considerable advantages over the opaque globes hitherto employed for that purpose. The globes operate by absorbing the light until they become luminous—a process in which a considerable pro-

portion of the light is wasted. M. Clémandot aims by his process to make all the light available for illumination. It is based on the principle which governs the diffusion of the light of the sun. This is effected by vapors floating between us and the sun, which distribute the light equally without stopping more than a very small proportion of it. To imitate these vapors he uses a solid substance, but in a condition so attenuated as to be, for practical purposes, almost the same as vaporous. It is glass, spun into threads one hundred and seventy-five times finer than a hair, or forty-five times finer than the finest silk fiber, with which he surrounds the light with a double envelope. His glass-fleeces are put into a lantern constructed especially for the purpose, so as to exclude dust, the glasses of which may be given any desired degree of opacity, and any color, including those colors which will neutralize the injurious properties of the electric light. The apparatus can be adapted to any of the systems of electrical lighting.

William Lassell.—William Lassell, LL. D., F. R. S., the famous astronomer and maker of telescopes, died October 5th, in the eighty-second year of his age. His name is closely associated with the history of the reflecting telescope. About 1820, not having sufficient means to enable him to buy expensive instruments, he began to construct reflecting telescopes for himself, beginning with a Newtonian and a Gregorian telescope of seven-inch aperture, with which he succeeded so well that he was encouraged to make a Newtonian instrument of nine-inch aperture. In 1844 he began an instrument of two feet aperture and twenty feet focal length, in the making of which he introduced many improvements over the similar instrument of the Earl of Rosse. With this instrument he discovered the satellite of Neptune in 1846, the eighth satellite of Saturn, simultaneously with Professor Bond, in the United States, in 1848, and two satellites in addition to the two already known, of Uranus, in 1851. He afterward made an instrument of four-feet aperture and thirty-seven feet focus, which he set up at Malta, and with which he made numerous observations of nebulæ and planets, besides preparing a catalogue of six hundred new nebulæ discovered at Malta. His latest recorded work was the construction of an improved form of machine for polishing large telescopic mirrors, which is described in the "Transactions of the Royal Society" for 1874.

Climatology of Europe. — The climate of Western Europe is ameliorated by the warmth of the Gulf Stream in winter, and by the neighborhood of the ocean in summer, and approaches what is called an insular climate. In Eastern Europe these modifying influences cease to be felt, and the climate gradually assumes a continental character, with greater differences of temperature, colder winters and warmer summers. The differences in the summer temperatures of the eastern and western regions are less marked than those in the winter temperatures, and amount at most to about 27°. For the greater part of the continent the difference in the temperature of July is not more than about 18°. The mildest summers are felt in Ireland and Norway, and the hottest in Southeastern Europe. The difference is perceptible between places in corresponding latitudes in the southeast and southwest. Thus, Syracuse is 7° and Sebastopol is $5\frac{1}{2}$° warmer in July than Lisbon and Oporto. A similar difference, but less in extent, appears in going eastward along the northern parallels. The differences in the winter temperatures of the several parts of the continent are much more marked than are those of the summer temperatures. The mildest winters are felt along the Mediterranean coast and in the Iberian Peninsula, where the mean temperature in January is from 16° to 19°. The next mildest are those of the western coast of France and the southern coast of England and Ireland. The winters of western Scotland and the Orkney and Faroe Islands are milder than those of Berlin and Milan; those of the Arctic coasts of Scandinavia than those of the Gulf of Bothnia, as is shown by the fact that the Arctic fiords of Norway, even as far as North Cape, are not frozen, while the Gulf of Bothnia is regularly frozen in winter. In Russia the January temperature diminishes as we go east, so that, while it is about 24° at Warsaw, it is reduced to 4° at Uralsk. The highest annual mean temperature, the

mildest winters and the warmest summers, must be looked for where the land approaches the thirty-fifth parallel, at the southern points of Spain, Sicily, and Crete. The highest known mean in Europe is at Catania, 65°, the temperature of January being there 51°, and that of August 81°. Gibraltar enjoys a warmer temperature in January, 54°, nearly corresponding with the temperature of Cairo. The January of Catania is like that of the end of April, the January of Gibraltar like that of the first half of May, in Berlin. These extreme southern points suffer, however, occasionally from frost and snow. Snow fell on the African coast in 1845 and 1850, and in the latter year a temperature below the freezing-point was observed as far south as the Sahara; and the Nile is said to have been frozen in the year 859. So it is safe to assume that no place in Europe is secure from snow and frost.

A New Theory of Chemical Affinity.—M. Berthelot has endeavored, in his recently published "Essai de Mécanique Chimique fondée sur la Thermochimie," to connect the laws of chemistry and the theory of the unity of physical forces. He believes that he has discovered a direct relation between chemical affinity and the capacity of different bodies in combining to throw off heat. Thus hydrogen burns in oxygen, liberating enormous quantities of heat; the affinity of the two bodies is known to be strong. The same is the case with phosphorus and oxygen. But nitrogen and hydrogen, instead of liberating heat when they combine, absorb it. Their affinity for each other is feeble. Again, when two bodies combine in different proportions, forming different compounds, it is always the combination in which the most heat is liberated that tends to form. More heat is liberated in the formation of water than of the binoxide of hydrogen, and it is water that is naturally formed when the bodies burn together. This law of chemical compositions and decompositions has been termed by M. Berthelot the *principle of maximum work*, and is enunciated by him thus: Every chemical change accomplished without intervention of a foreign energy (heat, electricity, light) tends to the production of the body or system of bodies which liberates heat. This principle throws light on a multitude of facts hitherto unexplained. M. Berthelot indicates many applications of his principle. Acetic acid, combining with soda, produces a certain amount of heat, and forms acetate of soda; hydrochloric acid, combining with soda, liberates more heat, and forms chloride of sodium. If, now, we apply hydrochloric acid to the acetate of soda, chloride of sodium will be formed, with the production of an amount of heat just equal to the difference between the heat of formation of acetate of soda and that of chloride of sodium; but the converse will not take place when acetic acid is mixed with chloride of sodium. Combinations which are formed with much liberation of heat are very stable; those in which heat is not liberated are unstable. Chloride of sodium will resist a white heat without decomposing, while chloride of nitrogen, in the formation of which heat is absorbed, will decompose and explode spontaneously. This fact leads to another remark: that, in accordance with the law of maximum work, all explosive bodies are bodies that produce heat in being decomposed.

Diseases of Miners.—Dr. Paul Fabre, of Commentry, France, has made a particular study of the diseases of miners. He has found that diseases, the character of which is largely governed by certain accessory circumstances, are prevalent among workmen who labor in damp or wet galleries. No morbid symptom is developed among those who work in a gallery which is simply damp and of a temperature of not more than 58°. But if cold water falls upon them, or if they have to put their legs in water, they become subject to lumbago, sciatica, to indefinite pains in their limbs, and often to a real rheumatism. The rheumatism is generally subacute, sometimes chronic, and most often localized in a single joint—generally that of the left knee, on which the pick-men and heavers rest in working. In galleries which are saturated with moisture and where the temperature exceeds 77° to 86°, the workmen are soon overcome with an extreme lassitude; they get hot, they gasp for breath, the sweat rolls down their bodies, and they are obliged to stop working and rest for a while in a cooler spot. A rapid

enervation which compels frequent changes of the men in the gallery, sudoral or miliary eruptions, sometimes boils, rarely eczema, are among the phenomena which Dr. Fabre has most frequently observed in these conditions. If, while the gallery is constantly damp, the air is vitiated by poisonous or irrespirable gases, and if the water contains sulphates or sulphuric acid in solution, the men, in addition to pains in their limbs and difficulties in breathing, experience lively itchings and painful smarts wherever the surface of the skin has been abraded. Those who have labored for a long time in the damp galleries contract a chronic inflammation of the gums, together with muscular pains in the limbs, and have often intestinal troubles and spots of purpura. These phenomena indicate the coming on of a mild form of scurvy. The remedies are to be found in whatever will improve the sanitary conditions of the mines and the homes of the miners, and in the usual applications for scurvy whenever the symptoms of that disease appear.

Variability of the Level of the Ocean.—M. H. Trautschald, of Moscow, lately sent in a paper to the Geological Society of France, maintaining that the level of the ocean was not invariable, in which he expressed the following conclusions: 1. The level of the sea has fallen, as parts of the earth's crust have risen from the bottom above its surface; 2. The surface of nearly all the continents has once been at the bottom of the sea, and has risen from the waters, partly in consequence of upheavals, partly in consequence of the retreat of the ocean; 3. When the continents have been formed, a part of the waters of the seas is carried away from them, and held on the land as lakes, rivers, eternal snows, and as a constituent of organic matter—thus the quantity of water in the ocean has been constantly diminished, and its level has fallen; 4. As the earth cools, ice accumulates near the poles and on the mountains, water is soaked down more deeply into the crust of the earth, and mineral hydrates are formed everywhere. It follows that the level of the sea has been gradually falling ever since water has existed as a liquid upon the earth.

Spiders and Tuning-Forks.—According to observations recorded by Mr. C. V. Boys, in "Nature," spiders are very sensibly affected by the vibrations of a tuning-fork, and act toward it as they would toward a fly that comes to their web. When a fork, lightly touching a leaf, or other support to the web, was sounded, the spider, if at the center of the web, would face the fork and feel with its fore-feet to find along which radial thread the vibration was traveling. Having become satisfied on this point, it would run along the proper thread till it reached the fork, or, if it came to the junction of two threads, would first stop and determine which was the right one. If the spider was not at the center of the web, and was not on a thread in contact with the fork, it had, when it perceived a vibration, to go to the center to see which radial thread was vibrating. It would then run out to the fork. If the fork was not removed when the spider had reached it, it would seize it, embrace it, and run along on the legs of the fork as often as it was made to sound, "never seeming to learn by experience that other things may buzz besides its natural food." If, when a spider had been enticed to the edge of the web, the fork was withdrawn, and then gradually brought near, the spider seemed aware of its presence and direction, and would reach out after it; but, if a sounding-fork was gradually brought near a spider that had not been disturbed, the spider would instantly drop; then, as soon as the fork was made to touch any part of the web, it would climb back and reach the fork with marvelous rapidity. By means of a tuning-fork a spider could be made to eat what it would otherwise avoid—even a fly dipped in paraffine—if its attention was kept fixed by the constant vibration of the fork.

Deterioration of Binding in Libraries.—Mr. H. A. Homes, in the "Library Journal," notices some causes additional to those arising from the use of gaslights, which may conduce to the deterioration of bindings in libraries. The modern methods of tanning do not give as durable a leather as the old processes, which it took months or years to complete. This may be the

reason that the goat-skins of Turkey, in the tanning of which there is nothing modern or "improved," are still recognized as furnishing the best leather for bindings. The sulphide of sodium that is sometimes used in tanning may supply a part of the sulphur that is complained of in modern libraries. A second cause is the practice of using split skins, which gives a binding only half as strong and lasting as the old whole skins; and a third cause may be found in the gases escaping from the hot-air furnaces with which libraries are warmed, which are hardly less destructive than the products of illumination, and are more constantly in action.

Mixed Education.—Professor Alexander Hogg, in a note reprinted from the "Proceedings of the National Educational Association," refers to the perplexities arising from mixing military with industrial education in the Agricultural and Mechanical College of Texas. A cadet failed to receive promotion at the hands of the faculty, and the board of directors confirmed their decision, and then turned out the whole faculty. Professor Hogg says that serious troubles have befallen these institutions in several States, and remarks: "With regard to the cause, I venture to suggest that it will be found that it has all grown out of the complications of attempting to run in the same institution these three leading features, viz., agricultural, mechanical, and military education. The military, so far as I have been able to learn (and this is corroborated by my personal experience), is the source of all the troubles. And this, I think, grows out of the further fact that the military, to be of any use whatever, must be thoroughly equipped in all its departments and requirements, while the act of Congress, granting lands for the support of these colleges, intended it should be secondary, and cultivated entirely as a means of discipline and good order—not at all intended to make proficients in arms, but simply as a gymnastic exercise."

Rate of Growth of Coral.—Light is thrown on the question of the rapidity with which corals grow, by the case of specimens of living coral which were recently found on the hull of the French man-of-war Dayot, after a cruise of a few months in the South Pacific Ocean. When the vessel reached Tahiti, several corals were discovered growing on the copper sheathing, the longest of which was a *fungia* of discoidal shape nine inches in diameter, and weighing when half dry two pounds and four ounces. The Dayot had entered tropical waters several months before, but had not made a long stay in any harbor until she reached the Gambier Islands, where she remained for two months in the still waters of a coral basin. Thence she sailed direct for Tahiti. A young *fungia* probably became attached to the sheathing of the ship in passing the reef, where the vessel rubbed, and grew to the size and weight it had attained when observed, in nine weeks.

NOTES.

Fleuss's diving apparatus, which we described several months ago, has been used with success at the Severn Tunnel by a professional diver, who with it reached the bottom of the shaft under thirty-five feet of water, and walked more than a thousand feet up a heading to close some sluices and shut an iron door. He was cut off from all communication for an hour and a half. The ordinary diving gear had been tried for this work without success, for the great length of tubing required in connection with it rendered its use impracticable.

The suffocation of infants by overlying in the night has recently been investigated by a London coroner, who found that the abuse of alcohol was the principal cause of this form of mortality. Most of the cases occur on Saturday nights following the weekly debauch of the poorer classes among which they happen. The mother goes to bed in a state of semi-intoxication, nurses the baby with alcohol-poisoned milk, and both sink into a sort of drunken stupor, of which the infant becomes the victim.

The death is announced of Francis Trevelyan Buckland, best known as Frank Buckland, a popular writer on subjects of natural history, and a constant contributor to "Land and Water." He was a son of Dean Buckland, author of the work on geology in the "Bridgewater Treatises," whch he edited in 1858, was himself a writer "who could seize with alacrity the popular side of a scientific question, but seldom went deeper," and was an authority on subjects relating to fish and fish-culture.

THOMAS RYMER JONES, Professor of Comparative Anatomy at King's College, London, has recently died. He was author of a "General Outline of the Animal Kingdom," which was forty years ago considered the best book of its kind in England.

THE apparatus invented by Mouchat for utilizing the direct rays of the sun as a source of power has been so improved by M. Pifre, a French engineer, that he claims to be able to make available eighty per cent. of the received heat of the sun.

THE organization of an entomological club has recently been completed in this city by the election of Professor A. R. Grote as President, M. Berthold Neumoegen as Treasurer, and Mr. Harry Edwards as Secretary. Its object is the promotion of entomological science, and the formation of a metropolitan collection of entomological objects. The constitution provides for the publication of a journal devoted to the different branches of entomology, the first number of which is issued for January of this year.

PROFESSOR HUXLEY, in a recent paper before the London Zoölogical Society, said he was not aware of any zoölogist who now maintains the independent creation hypothesis.

SIGNOR SERRANO FATIGATI has made researches into the influence of different colors on the development and respiration of the infusoriæ, which lead to the following conclusions: 1. Violet light promotes, green light retards, the development of these lower existences; 2. If a number of these organisms are put in distilled water, they will die quicker in a violet light than in a light of any other color; 3. The production of carbonic acid is greater in violet, less in green light, than in any other color; 4. All of these circumstances indicate that the respiration of the infusoriæ is faster in violet, and slower in green light, than in any other color.

DR. HENRY DRAPER having reported to the French Academy of Sciences that he had succeeded in taking distinct photographs of the nebula in Orion, which would be useful in the future to show if any change should take place in that object, M. Janssen has proposed that systematic stellar photography be undertaken at as great a number of observatories as possible. He is preparing to begin such a work at the observatory at Meudon, with which he is connected.

THE experimental electric railway proposed about a year ago by Siemens has been built between the Anhalter Station, in Berlin, and a suburb called Lichtenfeld. It was to be opened to the public about the first of February.

THE Boston Free Library contains three hundred and sixty thousand books, and last year there were taken out eleven hundred and sixty thousand volumes.

THE phylloxera has appeared in the Crimea, imported, it is supposed, with vines from France. It has extended very slowly hitherto; but fears are expressed that it may invade the wild vineyards of the country, when it might destroy all the vines in the valleys of the Rion and Kura Rivers.

THE sinking of the base of the French entrance to the Mont Cenis Tunnel has obliged the railway company to bore a new entrance, which has been begun a little over half a mile to one side of the present opening, and will join the old tunnel at a point about two thousand feet from its mouth.

IN Siberia, a country so rich in gigantic fossils, the body of a colossal rhinoceros has been discovered in the Werchojanski district. It was found on the bank of a small tributary to the Jana River, and was laid bare by the action of the water. Similar to the mammoth washed ashore by the Lena River in 1799, it is remarkably well preserved, the skin being unbroken and covered with long hair. Unfortunately, only the skull of this rare fossil has reached St. Petersburg, and a foot is said to be at Irkutsk, while the remainder was allowed to be washed away by the river soon after it had been discovered. The investigation of the skull gave the interesting result that this rhinoceros (*R. Merckii*) is a connecting form between the species now existing and the so-called *Rhinoceros tichorrhinus*, remains of which are not unfrequently found in the gravel strata of eastern Prussia. It is supposed that *R. Merckii* is the now extinct inhabitant of the eastern part of Siberia.—*Nature.*

DR. B. A. GOULD, Director of the Observatory at Cordoba, in the Argentine Republic, has been elected correspondent of the French Academy of Science, in the place of the late Professor C. A. F. Peters.

DIED in Liverpool, January 3, 1881, Mr. John T. Towson, aged seventy-seven years. Mr. Towson was well known for valuable investigations relative to the subject of navigation, especially the determination of quickest routes to trans-oceanic ports, and the deviation of the compasses on board of iron ships. In 1863 he prepared a manual entitled "Practical Information on the Deviation of the Compass, for the Use of Masters and Mates of Iron Ships," which was subsequently published by the English Board of Trade.

PROFESSOR HUXLEY has been appointed to the inspectorship of fisheries, a position made vacant by the death of Mr. Frank Buckland.

MICHEL CHASLES.

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THE DEVELOPMENT OF POLITICAL INSTITUTIONS.

By HERBERT SPENCER.

VI.—POLITICAL HEADS—CHIEFS, KINGS, ETC.

Of the three components of the triune political structure traceable at the outset, we have now to follow the development of the first. Already in the last two chapters something has been said, and more has been implied, respecting that most important differentiation which results in the establishment of a headship. What was there indicated under its general aspects has here to be elaborated under its special aspects.

"When Rink asked the Nicobarians who among them was the chief, they replied, laughing, how could he believe that *one* could have power against so many?" I quote this as a reminder that there is at first resistance to the assumption of supremacy by one member of a group—a resistance which, though in some types of men small, is in most considerable, and in a few very great. To instances already given of tribes practically chief-less, may be added, from America, the Haidahs, among whom "the people seemed all equal"; the Californian tribes, among whom "each individual does as he likes"; the Navajos, among whom "each is sovereign in his own right as a warrior"; and from Asia the Angamies, who "have no recognized head or chief, although they elect a spokesman, who, to all intents and purposes, is powerless and irresponsible."

Such small subordination as rude groups show occurs only when the need for joint action is imperative, and control is required to make it efficient. Instead of recalling before-named examples of temporary chieftainship, I may here give a few others. Of the Lower Californians we read, "In hunting and war they have one or more chiefs to lead them, who are selected only for the occasion." Of the Flatheads'

chiefs it is said that "with the war their power ceases." Among the Sound Indians the chief "has no authority, and only directs the movements of his band in warlike incursions."

As observed under another head, this primitive insubordination has greater or less play according as the environment and the habits of life hinder or favor coercion. The Lower Californians, above instanced as chief-less, Baegert says resemble "herds of wild swine, which run about according to their own liking, being together to-day and scattered to-morrow, till they meet again by accident at some future time." "The chief among the Chipewyans are now totally without power," says Franklin; and these people exist as small migratory bands. Of the Abipones, who are "impatient of agriculture and a fixed home," and "are continually moving from place to place," Dobrizhoffer writes, "they neither revere their cacique as a master, nor pay him tribute or attendance as is usual with other nations." The like holds under like conditions with other races remote in type. Of the Bedouins Burckhardt remarks, "The sheik has no fixed authority"; and, according to another writer, "A chief who has drawn the bond of allegiance too tight is deposed or abandoned, and becomes a mere member of a tribe, or remains without one."

And now, having noted the original absence of political control, the resistance it meets with, and the circumstances which facilitate evasion of it, we may ask, What causes aid its growth? There are several; and chieftainship becomes settled in proportion as they coöperate.

Among the members of the primitive group, slightly unlike in various ways and degrees, there is sure to be some one who has a recognized superiority. This superiority may be of several kinds, which we will briefly glance at.

Though in a sense abnormal, the cases must be noted in which the superiority is that of an alien immigrant. The head-men of the Khonds "are usually descended from some daring adventurer" of Hindoo blood. Forsyth remarks the like of "most of the chiefs" in the highlands of Central Asia. And the traditions of Bochica among the Chibchas, Amalivaca among the Tamanacs, and Quetzalcoatl among the Mexicans, imply kindred origins of chieftainships. Here, however, we are mainly concerned with superiorities arising within the tribe.

The first to be named is that which goes with seniority. Though age, when it brings incapacity, is often among rude peoples treated with such disregard that the old are killed or left to die, yet, so long as capacity remains, the greater experience accompanying age generally insures influence. The chief-less Esquimaux show "deference to seniors and strong men." Burchell says that, over the Bushmen, old men seem to exercise the authority of chiefs to some extent; and

the like is true with the natives of Australia. By the Fuegians "the word of an old man is accepted as law by the young people." Each party of Rock Veddahs "has a head-man, the most energetic senior of the tribe," who divides the honey, etc. Even with sundry peoples more advanced the like holds. The Dyaks in north Borneo "have no established chiefs, but follow the counsels of the old man to whom they are related"; and Edwards says of the ungoverned Caribs, that "to their old men, indeed, they allowed some kind of authority."

Naturally, in rude societies, the strong hand gives predominance. Apart from the influence of age, "bodily strength alone procures distinction among" the Bushmen. The leaders of the Tasmanians were tall and powerful men: "Instead of an elective or hereditary chieftaincy, the place of command was yielded up to the bully of the tribe." A remark of Sturt's implies a like origin of supremacy among the Australians. Similarly in South America. Of people on the Tapajos, Bates tells us that "the foot-marks of the chief could be distinguished from the rest by their great size and the length of the stride." And in Bedouin tribes "the fiercest, the strongest, and the craftiest obtains complete mastery over his fellows." During higher stages physical vigor long continues to be an all-important qualification; as in Homeric Greece, where even age did not compensate for decline of strength: "an old chief, such as Peleus and Laertes, can not retain his position." And throughout mediæval Europe maintenance of headship largely depended on bodily prowess.

Mental superiority, alone or joined with other attributes, is a common cause of predominance. With the Snake Indians, the chief is no more than "the most confidential person among the warriors." Schoolcraft says of the chief acknowledged by the Creeks, that "he is eminent with the people only for his superior talents and political abilities"; and that over the Comanches "the position of a chief is not hereditary, but the result of his own superior cunning, knowledge, or success in war." A chief of the Coroados is one "who, by his strength, cunning, and courage, had obtained some command over them." And the Ostiaks "pay respect, in the fullest sense of the word, to their chief, if wise and valiant; but this homage is voluntary, and not a prerogative of his position."

Yet another source of governmental power in primitive tribes is largeness of possessions; wealth being at once an indirect mark of superiority and a direct cause of influence. With the Tacullies "any person may become a *minty*, or chief, who will occasionally provide a village feast." "Among the Tolewas, in Del Norte County, money makes the chief." And, of the chief-less Navajos we read that "every rich man has many dependents, and these dependents are obedient to his will, in peace and in war."

But, naturally, in societies not yet politically developed, acknowledged superiority is ever liable to be competed with or replaced by

superiority arising afresh. "If an Arab, accompanied by his own relations only, has been successful on many predatory excursions against the enemy, he is joined by other friends; and, if his success still continues, he obtains the reputation of being '*lucky*'; and he thus establishes a kind of second, or inferior, agydship in the tribe." So in Sumatra: "A commanding aspect, an insinuating manner, a ready fluency in discourse, and a penetration and sagacity in unraveling the little intricacies of their disputes, are qualities which seldom fail to procure to their possessor respect and influence, sometimes, perhaps, superior to that of an acknowledged chief." And supplantings of kindred kinds occur among the Tongans and the Dyaks.

At the outset, then, what we before distinguished as the principle of efficiency is the sole principle of organization. Such political headship as exists is acquired by one whose fitness asserts itself in the form of greater age, superior prowess, stronger will, wider knowledge, quicker insight, or larger wealth. But, evidently, supremacy which thus depends exclusively on personal attributes is but transitory. It is ever liable to be superseded by the supremacy of some more able man from time to time arising; and, if not superseded, is inevitably ended by death. We have, then, to inquire how permanent chieftainship becomes established. Before doing this, however, we must consider more fully the two kinds of superiority which especially conduce to chieftainship, and their modes of operation.

As bodily vigor is a cause of predominance within the tribe on occasions daily occurring, still more on occasions of war is it, when joined with courage, a cause of predominance. War, therefore, ever tends to make more pronounced any authority of this kind which is incipient. Whatever reluctance other members of the tribe have to recognize the leadership of any one member is likely to be overridden by their desire for safety when recognition of his leadership furthers that safety.

This rise of the strongest and most courageous warrior to power is at first spontaneous, and afterward by agreement more or less definite; sometimes joined with a process of testing. Where, as in Australia, each "is esteemed by the rest only according to his dexterity in throwing or evading a spear," it is inferable that such superior capacity for war as is displayed generates of itself such temporary chieftainship as exists. Where, as among the Comanches, any one who distinguishes himself by taking many "horses or scalps may aspire to the honors of chieftaincy, and is gradually inducted by a tacit popular consent," this natural genesis is clearly shown us. Very commonly, however, there is deliberate choice; as by the Flatheads, among whom, "except by the war-chiefs, no real authority is exercised." By some of the Dyaks, both strength and courage are tested. "The ability to climb up a large pole, well greased, is a necessary qualification of a fighting chief

among the Sea Dyaks" ; and St. John says that, in some cases, it was a custom, in order to settle who should be chief, for the rivals to go out in search of a head, the first in finding one being victor.

Moreover, the need for an efficient leader tends ever to reëstablish chieftainship where it is only nominal or feeble. Edwards says of the Caribs that, "in war, experience had taught them that subordination was as requisite as courage ; they therefore elected their captains in their general assemblies with great solemnity," and "put their pretensions to the proof with circumstances of outrageous barbarity." Similarly, "although the Abipones neither fear their cacique as a judge, nor honor him as a master, yet his fellow-soldiers follow him as a leader and governor of the war, whenever the enemy is to be attacked or repelled."

These and like facts, of which there are abundance, have three kindred implications. One is that continuity of war conduces to permanence of chieftainship. A second is that, with increase of his influence as successful military head, the chief gains influence as political head. A third is that there is thus initiated a union, maintained through subsequent phases of social evolution, between military supremacy and political supremacy. Not only among the uncivilized Hottentots, Malagasy, and others is the chief or king head of the army—not only among such semi-civilized peoples as the ancient Peruvians and Mexicans do we find the monarch one with the commander-in-chief, but the histories of extinct and surviving nations all over the world exemplify the connection. In Egypt, "in the early ages, the offices of king and general were inseparable." Assyrian records represent the political head as also the conquering soldier ; as do the records of the Hebrews. Civil and military supremacy were united among the Homeric Greeks ; and in primitive Rome "the general was ordinarily the king himself." That throughout European history it has been so, and partially continues so even now in the more militant societies, needs no showing.

How command of a wider kind follows military command we can not readily see in societies which have no records ; we can but infer that, along with increased power of coercion which the successful head warrior gains, naturally goes the exercise of a stronger rule in civil affairs. That this has been so among peoples who have histories there is proof. Of the primitive Germans Sohm remarks that the Roman invasions had one result : "The kingship became united with the leadership (become permanent) of the army, and, as a consequence, raised itself to a *power* [institution] in the state. The military subordination under the king-leader furthered political subordination under the king. . . . Kingship after the invasions is a kingship clothed with supreme rights—a kingship in our sense." In like manner it is observed by Ranke that, during the wars with the English in the fifteenth century, "the French monarchy, while struggling for its very existence, ac-

quired at the same time, and as the result of the struggle, a firmer organization. The expedients adopted to carry on the contest grew, as in other important cases, to national institutions." And modern instances of the relation between successful militancy and the strengthening of political control are furnished by the career of Napoleon and the recent history of the German Empire.

Political headship, then, commonly beginning with the influence gained by the strongest, most courageous, and most astute warrior, becomes established where activity in war gives opportunity for his superiority to show itself and to generate subordination; and thereafter the growth of political power continues primarily related to the exercise of militant functions.

Very erroneous, however, would be the idea formed if no further origin for political headship were named. There is a kind of influence, in some cases operating alone and in other cases coöperating with that above specified, which is all-important. I mean the influence possessed by the medicine-man.

That this arises as early as the other can scarcely be said; since, until the ghost-theory takes shape, there is no origin for it. But, when belief in the spirits of the dead becomes current, the medicine-man, professing ability to control them and inspiring faith in his pretensions, is regarded with a fear which prompts obedience. When we read of the Thlinkeets that "the supreme feat of a conjurer's power is to throw one of his liege spirits into the body of one who refuses to believe in his power, upon which the possessed is taken with swooning and fits," we may imagine the dread he excites and the sway he consequently gains. From some of the lowest races upward we find illustrations. Fitzroy says of the "doctor-wizard among the Fuegians" that he is the most cunning and most deceitful of his tribe, and that he has great influence over his companions. "Though the Tasmanians were free from the despotism of rulers, they were swayed by the counsels, governed by the arts, or terrified by the fears of certain wise men or doctors. These could not only mitigate suffering but inflict it." A chief of the Haidahs "seems to be the principal sorcerer, and indeed to possess little authority save from his connection with the preterhuman powers." The Dakota medicine-men "are the greatest rascals in the tribe, and possess immense influence over the minds of the young, who are brought up in the belief of their supernatural powers. . . . The war-chief who leads the party to war is always one of these medicine-men, and is believed to have the power to guide the party to success, or save it from defeat." Among more advanced peoples in Africa, supposed powers of working supernatural effects similarly give influence, strengthening authority otherwise gained. It is so with the Amazulu: a chief "practices magic on another chief before fighting with him"; and his followers have great confidence in him if he has

much repute as a magician. Hence the power possessed by Langalibalele, who, as Bishop Colenso says, "knows well the composition of that *intelezi* [used for controlling the weather]; and he knows well, too, the war-medicine, i. e., its component parts, being himself a doctor." Still better is seen the governmental influence thus acquired in the case of the king of Obbo, who in time of drought calls his subjects together and explains to them "how much he regrets that their conduct has compelled him to afflict them with unfavorable weather, but that it is their own fault. . . . He must have goats and corn. 'No goats, no rain; that's our contract, my friends,' says Katchiba. . . . Should his people complain of too much rain, he threatens to pour storms and lightning upon them for ever, unless they bring him so many hundred baskets of corn, etc. . . . His subjects have the most thorough confidence in his power." And the king is similarly supposed to have power over the weather among the people of Loango.

A like connection is traceable in the records of various extinct peoples in both hemispheres. Of Huitzilopochtli, the founder of the Mexican power, we read that "a great wizard he had been, and a sorcerer"; and every Mexican king on ascending the throne had to swear "to make the sun go his course, to make the clouds pour down rain, to make the rivers run, and all fruits to ripen." Reproaching his subjects for want of obedience, a Chibcha ruler told them they knew that "it was in his power to afflict them with pestilence, smallpox, rheumatism, and fever, and to make to grow as much grass, vegetables, and plants as they wanted." Ancient Egyptian records yield indications of a similar early belief. Thothmes III, after being deified, "was considered as the luck-bringing god of the country, and a preserver against the evil influence of wicked spirits and magicians." And it was thus with the Jews: "Rabbinical writers are never weary of enlarging upon the magical power and knowledge of Solomon. He was represented as not only king of the whole earth, but also as reigning over devils and evil spirits, and having the power of expelling them from the bodies of men and animals, and also of delivering people to them." The traditions of European peoples furnish kindred evidence. As before shown, stories in the "Heims-kringla Saga" imply that the Scandinavian ruler, Odin, was a medicine-man; as were also Niot and Frey, his successors. And after recalling the supernatural weapons and supernatural achievements of early heroic kings, we can scarcely doubt that with them were in some cases associated the supposed magical powers whence have descended the supposed powers of kings to cure diseases by touching or otherwise. We shall the less doubt this on finding that like powers were ascribed to subordinate rulers of early origin. There were certain ancient Breton nobles whose spittle and touch had curative properties.

One important factor, then, in the genesis of political headship,

originates with the ghost-theory, and the concomitant rise of a belief that some men, having acquired power over ghosts, can obtain their aid. Generally the chief and the medicine-man are separate persons; and there then exists between them some conflict: they have competing authorities. But, where the ruler unites with his power, naturally gained, this ascribed supernatural power, his authority is necessarily much increased. Recalcitrant members of his tribe, who might dare to resist him if bodily prowess alone could decide the struggle, do not dare to do this if they believe he can send one of his *posse comitatus* of ghosts to torment them. That rulers desire to unite the two characters we have, in one case, distinct proof. Canon Callaway tells us that, among the Amazulu, a chief will endeavor to discover a medicine-man's secrets and afterward kill him.

Still there recurs the question, How does permanent political headship arise? Such political headship as results from bodily power, or courage, or sagacity, even when strengthened by supposed supernatural aid, ends with the life of any savage who gains it. The principle of efficiency, physical or mental, while it tends to produce a temporary differentiation into ruler and ruled, does not suffice to produce a permanent differentiation. There has to coöperate another principle, to which we now pass.

Already we have seen that even in the rudest groups age gives some predominance. Among both Fuegians and Australians, not only old men, but old women, exercise authority. And that this respect for age, apart from other distinction, is an important factor in establishing political subordination, is implied by the curious fact that, in sundry advanced societies characterized by extreme governmental coercion, the respect due to age takes precedence of all other respect. Sharpe remarks of ancient Egypt that "here as in Persia and Judea the king's mother often held rank above his wife." In China, notwithstanding the inferior position of women socially and domestically, there exists this supremacy of the female parent, second only to that of the male parent; and the same thing occurs in Japan. As supporting the inference that subjection to parents prepares the way for subjection to rulers, I may add a converse fact. Of the Coroados, whose groups are so incoherent, we read that "the *pajé*, however, has as little influence over the will of the multitude as any other, for they live without any bond of social union, neither under a republican nor a patriarchal form of government. Even family ties are very loose among them . . . there is no regular precedency between the old and the young, for age appears to enjoy no respect among them." And, as reënforcing this converse fact, I may add that, as I have shown elsewhere, the Mantras, the Caribs, the Mapuchés, the Brazilian Indians, the Gallinomeros, the Shoshones, the Navajos, the Californians, the Comanches, who submit very little or not at all to

chiefly rule, display a filial submission which is mostly small and ceases early.

But now under what circumstances does respect for age take that pronounced form seen in societies distinguished by great political subordination? It was pointed out that when men, passing from the hunting stage into the pastoral stage, began to wander in search of food for their domesticated animals, they fell into conditions favoring the formation of that patriarchal group, at once family and miniature society, constituting the unit of composition of societies which reach the highest stages of evolution. We saw that, in the primitive pastoral horde, the man, dissociated from those earlier tribal influences which interfere with paternal power, and which prevent settled relations of the sexes, was so placed as to acquire headship of a coherent group: the father became, "by right of the strong hand, leader, owner, master, of wife, children, and all he carried with him." There were enumerated the influences which tended to make the eldest male a patriarch; and it was shown that not only the Semites, Aryans, and Turanians have exemplified this relation between pastoral habits and the patriarchal organization, but that it recurs in South African races.

Be the causes what they may, however, we find abundant proof that this family supremacy of the eldest male, common among pastoral peoples and peoples who have passed through the pastoral stage into the agricultural stage, naturally develops into political supremacy. Of the Santals Hunter says: "The village government is purely patriarchal. Each hamlet has an original founder (the manjhi-hanan), who is regarded as the father of the community. He receives divine honors in the sacred grove and transmits his authority to his descendants." Of the compound family among the Khonds we read in Macpherson that "there it [paternal authority] reigns nearly absolute. It is a Khond's maxim that a man's father is his god, disobedience to whom is the greatest crime; and all the members of a family live united in strict subordination to its head until his death." And the growth of groups thus arising, into compound and doubly compound groups, acknowledging the authority of one who unites family headship with political headship, has been made familiar by Sir Henry Maine and others as common to early Greeks, Romans, Teutons, and as still affecting social organization among Hindoos and Slavs.

Here, then, we have making its appearance a factor which conduces to permanence of political headship. As was pointed out in a foregoing chapter, while succession by efficiency gives plasticity to social organization, succession by inheritance gives it stability. No settled arrangement can arise in a primitive community so long as the function of each unit is determined exclusively by his fitness; since, at his death, the arrangement, in so far he was a part of it, must be recommenced. Only when his place is forthwith filled by one whose claim is admitted, does there begin a differentiation which survives

through successive generations. And evidently in the earlier stages of social evolution, while the coherence is small and the want of structure great, it is requisite that the principle of inheritance should, especially in respect of the political headship, predominate over the principle of efficiency. Contemplation of the facts will make this clear.

Two primary forms of hereditary succession have to be considered. The system of kinship through females, common among rude peoples, results in descent of property and power to brothers or to the children of sisters; while the system of kinship through males, general among advanced peoples, results in descent of property and power to sons or daughters. We have first to note that succession through females results in less stable political headships than does succession through males.

From the fact named, when treating of the domestic relations, that the system of kinship through females arises where unions of the sexes are temporary or unsettled, it is to be inferred that this system characterizes societies which are unadvanced in all ways, political included. We saw that irregular connections involve paucity and feebleness of known relationships, and a type of family the successive links of which are not strengthened by so many collateral links. A common consequence is, that along with descent through females there goes either no chieftainship, or chieftainship is established by merit, or, if hereditary it is usually unstable. The Australians and Tasmanians may be named as typical instances. Among the Haidahs and other savage peoples of Columbia "rank is nominally hereditary, for the most part by the female line"; and actual chieftainship "depends to a great extent on wealth and ability in war." Of other North American tribes, the Chippewas, Comanches, and Snakes, show us the system of kinship through females joined with either absence of hereditary chieftainship or very feeble development of it. Passing to South America, the Arawaks and the Waraus may be instanced as having female descent and almost nominal though hereditary chiefs; and much the same may be said of the Caribs.

A group of facts having much significance may now be noted. In many societies where descent of property and rank in the female line is the rule, an exception is made in the case of the political head; and the societies exemplifying this exception are societies in which political headship has become relatively stable. Though in Feejee there is kinship through females, yet, according to Seemann, the ruler, chosen from the members of the royal family, is "generally the son" of the late ruler. In Tahiti, where the two highest ranks follow the primitive system of descent, male succession to rulership is so pronounced that, on the birth of an eldest son, the father becomes simply a regent on his behalf. And among the Malagasy, along with a prevailing kinship through females, the sovereign either nominates his successor, or,

failing this, the nobles appoint, and, "unless positive disqualification exists, the eldest son is usually chosen." Africa furnishes evidence of varied kinds. Though the Congo people, the coast negroes, and the inland negroes, have formed societies of some size and complexity, notwithstanding that kinship through females obtains in the succession to the throne, yet we read of the first that allegiance is "vague and uncertain"; of the second, that, save where free in form, the government is "an insecure and short-lived monarchic despotism"; and of the third, that, where the government is not of mixed type, it is "a rigid but insecure despotism." Meanwhile, in the two most advanced and powerful states, stability of political headship goes along with departure, partial or complete, from succession through females. In Ashantee the order of succession is "the brother, the sister's son, the son"; and in Dahomey there is male primogeniture. Further instances of this transition are yielded by extinct American civilizations. Though the Aztec conquerors of Mexico brought with them the system of kinship through females, and consequent law of succession, yet this law of succession was partially, or completely, changed to succession through males. In Tezcuco and Tlacopan (divisions of Mexico) the eldest son inherited the kingship; and in Mexico the choice of a king was limited to the sons and brothers of the preceding king. Then, of ancient Peru, Gomara says, "Nephews inherit, and not sons, except in the case of the Incas": this exception in the case of the Incas having the strange peculiarity that "the first-born of this brother and sister [i. e., the Inca and his principal wife] was the legitimate heir to the kingdom"—an arrangement which made the line of descent unusually narrow and definite. And here we are brought back to Africa by the parallelism between the case of Peru and that of Egypt. "In Egypt it was maternal descent that gave the right to property and to the throne. The same prevailed in Ethiopia. If the monarch married out of the royal family, the children did not enjoy a legitimate right to the crown." When we add the statement that the monarch was "supposed to be descended from the gods, in the male and female line," and when we join with this the further statement that there were royal marriages between brother and sister, we see that like causes worked like effects in Egypt and in Peru. For in Peru the Inca was of supposed divine descent; inherited his divinity on both sides; and married his sister to keep the divine blood unmixed. And in Peru as in Egypt there resulted royal succession in the male line, where, otherwise, succession through females prevailed.

With this process of transition from the one law of descent to the other, implied by these last facts, may be joined some processes which preceding facts imply. In New Caledonia a "chief nominates his successor, if possible, in a son or brother": the one choice implying descent in the male line and the other being consistent with descent in either male or female line. And in Madagascar, where the system of

female kinship prevailed, "the sovereign nominated his successor—naturally choosing a son." Further, it is to be noted that, where, as in these cases, when no nomination has been made, the nobles choose among members of the royal family, and are determined in their choice by eligibility, there may be, and naturally is, a departure from descent in the female line; and this once broken through is likely, for several reasons, to be abolished. We are also introduced to another transitional process. For some of these cases are among the many in which succession to rulership is fixed in respect of the family, but not fixed in respect of the member of the family—a stage implying a partial but incomplete stability of the political headship. Several instances occur in Africa. "The crown of Abyssinia is hereditary in one family, but elective in the person," says Bruce. "Among the Timmanees and Bulloms, the crown remains in the same family, but the chief or head-men of the country, upon whom the election of a king depends, are at liberty to nominate a very distant branch of that family." And a Caffre "law requires the successor to the king should be chosen from among some of the youngest princes." In Java and Samoa, too, while succession to rulership is limited to the family, it is but partially settled with respect to the individual.

That stability of political headship is secured by establishment of descent in the male line is, of course, not alleged. The assertion simply is, that succession after this mode conduces better than any other to its stability. Of probable reasons for this, one is that in the patriarchal group, as developed among those pastoral races from which the leading civilized peoples have descended, the sentiment of subordination to the eldest male, fostered by circumstances in the family and in the gens, becomes instrumental to a wider subordination in the larger groups eventually formed. Another probable reason is, that with descent in the male line there is more frequently a union of efficiency with supremacy. The son of a great warrior, or man otherwise capable as a ruler, is more likely to possess kindred traits than is the son of his sister; and, if so, it will happen that in those earliest stages, when personal superiority is requisite as well as legitimacy of claim, succession in the male line will conduce to maintenance of power by making usurpation more difficult.

There is, however, a more potent influence which aids in giving permanence to political headship, and which operates more in conjunction with descent through males than in conjunction with descent through females—an influence probably of greater importance than any other.

When showing how respect for age generates patriarchal authority where descent through males has arisen, I gave cases which incidentally showed a further result; namely, that the dead patriarch, worshiped by his descendants, becomes a family deity. In sundry chap-

ters of Vol. I were set forth at length the proofs, past and present, furnished by many places and peoples, of this genesis of gods from propitiated ghosts. Here there remains to be pointed out the strengthening of political headship inevitably thus effected.

Descent from a ruler who when alive was distinguished by superiority, and whose ghost, specially feared, comes to be propitiated in so unusual a degree as to distinguish it from ancestral ghosts at large, exalts and supports the living ruler in two ways. In the first place, he is assumed to inherit from his great progenitor more or less of the character, apt to be considered supernatural, which gave him his power; and, in the second place, making sacrifices to this great progenitor, he is supposed to maintain such relations with him as insure divine aid. Passages in Canon Callaway's account of the Amazulu show the influence of this belief. It is said, "The itongo [ancestral ghost] dwells with the great man, and speaks with him"; and then it is also said, referring to a medicine-man: "The chiefs of the house of Uzulu used not to allow a mere inferior to be even said to have power over the heaven; for it was said that the heaven belonged only to the chief of that place." These facts yield us a definite interpretation of others, like the following, which show that the authority of the terrestrial ruler is increased by his supposed relation to the celestial ruler; be the celestial the ghost of the remotest known ancestor who founded the society, or of a conquering invader, or of a superior stranger.

Of the chiefs among the Kukis, who are descendants of Hindoo adventurers, we read: "All these rajahs are supposed to have sprung from the same stock, which it is believed originally had connection with the gods themselves; their persons are therefore looked upon with the greatest respect and almost superstitious veneration, and their commands are in every case law." Of the Tahitians Ellis says: "The god and the king were generally supposed to share the authority over the mass of mankind between them. The latter sometimes impersonated the former. . . . The kings, in some of the islands, were supposed to have descended from the gods. Their persons were always sacred." According to Mariner, "*Toritonga* and *Veachi* (hereditary divine chiefs in Tonga) are both acknowledged descendants of chief gods who formerly visited the islands of Tonga." And, in ancient Peru, "the Inca gave them (his vassals) to understand that all he did with regard to them was by an order and revelation of his father, the Sun."

This reënforcement of natural power by supernatural power becomes extreme where the ruler is at once a descendant of the gods and himself a god; a union of attributes which is familiar among peoples who do not distinguish between the divine and the human as we do. It was thus in the case just instanced—that of the Peruvians. It was thus with the ancient Egyptians. The monarch "was the rep-

resentative of the Divinity on earth, and of the same substance"; and not only did he in many cases become a god after death, but he was worshiped as a god during life; as witness the following prayer to Rameses II:

When they had come before the king . . . they fell down to the ground, and with their hands they prayed to the king. They praised this divine benefactor, . . . speaking thus: "We are come before thee, the lord of heaven, lord of the earth, sun, life of the whole world, lord of time, . . . lord of prosperity, creator of the harvest, fashioner and former of mortals, dispenser of breath to all men; animater of the whole company of the gods, . . . thou former of the great, creator of the small, . . . thou our lord, our sun, by whose words out of his mouth Tum lives, . . . grant us life out of thy hands . . . and breath for our nostrils."

This prayer introduces us to a remarkable parallel. Rameses, whose powers, demonstrated by his conquests, were regarded as so transcendent, is here described as ruling not only the lower world but also the upper world; and a like royal power is alleged in two existing societies where absolutism is similarly unmitigated—China and Japan. As shown when treating of "Ceremonial Institutions," both the Emperor of China and the Japanese Mikado have such supremacy in heaven that they promote its inhabitants from rank to rank at will.

That this strengthening of political headship, if not by ascribed godhood then by ascribed descent from a god (either the apotheosized ancestor of the tribe or one of the elder deities), was exemplified among the early Greeks, needs not be shown. It was exemplified, too, among the Northern Aryans. "According to the old heathen faith, the pedigree of the Saxon, Anglian, Danish, Norwegian, and Swedish kings—probably also those of the German and Scandinavian kings generally—was traced to Odin, or to some of his immediate companions or heroic sons."

It is further to be noticed that a god-descended ruler who is also chief priest of the gods (as he habitually is) obtains a more effectual supernatural aid than does the ruler to whom magical powers alone are ascribed. For in the first place the invisible agents invoked by the magician are not conceived to be those of highest rank; whereas the divinely-descended ruler is supposed to get the help of a supreme invisible agent. And, in the second place, the one form of influence over these dreaded superhuman beings tends much less than the other to become a permanent attribute of the ruler. Though among the Chibchas we find a case in which magical power was transferred to a successor—though "the cacique of Sogamoso made known that he [Bochica] had left him heir of all his sanctity, and that he had the same power of making rain when he liked," and giving health or sickness (an assertion believed by the people)—yet this is an exceptional case. Speaking generally, the chief whose relations with the supernatural world are those of a sorcerer does not transmit his relations; and he

does not, therefore, establish a supernatural dynasty, as does the chief of divine descent.

And now, having considered the several factors which coöperate to establish political headship, let us consider the process of coöperation through its ascending stages. The truth to be noted is, that the successive phenomena which occur in the simplest groups habitually recur in the same order in compound groups, and again in doubly compound groups.

As, in the simple group, there is at first a state in which there is no headship, so, when simple groups which have political heads possessing slight authorities are associated, there is at first no headship of the cluster. The Chinooks furnish an example. Describing them, Lewis and Clarke say: "As these families gradually expand into bands, or tribes, or nations, the paternal authority is represented by the chief of each association. This chieftain, however, is not hereditary." And then comes the further fact, which here specially concerns us, that "the chiefs of the separate villages are independent of each other": there is no general chieftainship.

As headship in the simple group, at first temporary, ceases when the war which initiates it ends, so, in the cluster of groups which severally have recognized heads, a common headship at first results from a war, and lasts no longer than the war. Falkner says, "In a general war, when many nations enter into an alliance against a common enemy," the Patagonians "chose an *apo*, or commander-in-chief, from among the oldest or most celebrated of the caciques." The Indians of the upper Orinoco live "in hordes of forty or fifty under a family government, and they recognize a common chief only in times of war." So is it in Borneo. "During war the chiefs of the Sarebas Dyaks give an uncertain allegiance to a head chief, or commander-in-chief." It has been the same in Europe. Seeley remarks that the Sabines "seem to have had a central government only in war-time." Again: "Germany had anciently as many republics as it had tribes. Except in time of war, there was no chief common to all, or even to any given confederation."

This recalls the fact indicated when treating of political integration, that the cohesion within compound groups is less than that within simple groups, and again that the cohesion within the doubly compound less than that within the compound. What was there said of cohesion may here be said of subordination; for we find that, when by continuous war a permanent headship of a compound group has been generated, it is less stable than the headships of the simple groups. Often it lasts only for the life of the man who achieves it; as among the Karens and the Maganga, and as among the Dyaks, of whom Boyle says: "It is an exceptional case if a Dyak chief is raised to an acknowledged supremacy over the other chiefs. If he is so raised he

can lay no claim to his power except that of personal merit and the consent of his former equals; and his death is instantly followed by the disruption of his dominions." Even when there has arisen a headship of the compound group which lasts beyond the life of its founder, it remains for a long time not equal in stability to the headships of the component groups. Pallas, while describing the Mongol and Calmuck chiefs as having unlimited power over their dependents, says that the khan had in general only an uncertain and weak authority over the subordinate chiefs. Of the Caffres we read: "They are all vassals of the king, chiefs, as well as those under them; but the subjects are generally so blindly attached to their chiefs that they will follow them against the king." Europe has furnished kindred examples. Of the Homeric Greeks Mr. Gladstone writes: "It is probable that the subordination of the sub-chief to his local sovereign was a closer tie than that of the local sovereign to the head of Greece." And, during the early feudal period in Europe, allegiance to the local ruler was stronger than that to the general ruler.

In the compound group, as in the simple group, the progress toward stable headship is furthered by the transition from succession by choice to succession by inheritance. During early stages of the simple tribe, chieftainship, whe nnot acquired by individual superiority tacitly yielded to, is acquired by election. In North America it is so with the Aleuts, the Comanches, and many more; in Polynesia it is so with the Land Dyaks; and, before the Mohammedan conquest, it was so in Java. Among the hill-races of India it is so with the Nagas and others. In some regions the transition to hereditary succession is shown by different tribes of the same race. Of the Karens we read that "in many districts the chieftainship is considered hereditary, but in more it is elective." Some Chinook villages have chiefs who inherit their powers, though mostly they are chosen.

Similarly, the compound group is at first ruled by an elected head. Sundry examples come to us from Africa. Bastian says that "in many parts of the Congo region the king is chosen by the petty princes." The crown of Yariba is not hereditary—"the chiefs invariably electing, from the wisest and most sagacious of their own body." And the King of Ibu, says Allen, seems to be "elected by a council of sixty elders, or chiefs of large villages." In Asia it is thus with the Kukis: "One, among all the rajahs of each class, is chosen to be the Prudham or chief rajah of that clan. The dignity is not hereditary, as is the case with the minor rajahships, but is enjoyed by each rajah of the clan in rotation." So has it been in Europe. Though by the early Greeks hereditary right was in a considerable measure recognized, yet the case of Telemachus implies "that a practice, either approaching to election, or in some way involving a voluntary action on the part of the subjects, or of a portion of them, had to be gone through." The like is true of ancient Rome. That the monarchy was

elective "is proved by the existence in later times of an office of *interrex*, which implies that the kingly power did not devolve naturally upon an hereditary successor." Later on it was thus with Western peoples. Up to the beginning of the tenth century "the formality of election subsisted . . . in every European kingdom; and the imperfect right of birth required a ratification by public assent." And it was once thus with ourselves. Among the early English the bretwaldship, or supreme headship over the minor kingdoms, was at first elective; and the form of election continued long traceable in our history.

The stability of the compound headship, made greater by efficient leadership in war and by establishment of hereditary succession, is further increased when there coöperates the additional factor—supernatural origin or supernatural sanction. Everywhere, up from a New Zealand king who is strictly *tapu*, or sacred, we may trace this influence; and occasionally, where divine descent or magical powers are not claimed, there is a claim to origin that is more than human. Asia yields an example in the Fodli dynasty, which reigned a hundred and fifty years in south Arabia—a six-fingered dynasty, regarded with awe by the people because of its continuously-inherited malformation. Europe of the Merovingian period yields an example. In pagan times the king's race had an alleged divine origin; but in Christian times, says Waitz, as they could no longer mount back to the gods, the myth still clung to the supernatural: "A sea-monster ravished the wife of Chlogio as she sat by the seashore, and from this embrace Merovech sprang." Later days show us the gradual acquisition of a sacred or semi-supernatural character where it did not originally exist. Divine assent to their supremacy was alleged by the Carlovingian kings. During the later feudal age, rare exceptions apart, kings "were not far removed from believing themselves near relatives of the masters of heaven. Kings and gods were colleagues." In the seventeenth century this belief was justified by divines. "Kings," says Bossuet, "are gods, and share in a manner the divine independence."

So that the headship of a compound group, first arising temporarily during war, becoming with frequent coöperation of the groups settled for life, by election, passing presently into the hereditary form, and becoming more stable as fast as the law of succession becomes well defined and undisputed, acquires its greatest stability only when the king becomes a deputy-god, or when, if his supposed godlike nature is not, as in primitive societies, derived from alleged divine descent, it is replaced by a divine commission guaranteed by ecclesiastical authority.

Where the political head has acquired this absoluteness which results from supposed divine nature, or divine descent, or divine commission, there is naturally no limit to his sway. In theory, and often

to a large extent in practice, he is owner of his subjects and of the territory they occupy.

Where militancy is pronounced and the claims of a conqueror unqualified, it is indeed to a considerable degree thus with those uncivilized peoples who do not ascribe supernatural characters to their rulers. Among the Zooloo Caffres the chief "exercises supreme power over the lives of his people"; "the Bheel chiefs have a power over the lives and property of their own subjects"; and in Feejee the subject is property. But it is still more thus where the ruler is considered more than human. Astley tells us that in Loango the king is "called *samba* and *pongo*, that is, god"; and, according to Proyart, the Loango people "say their lives and goods belong to the king." In Wasoro, East Africa, "the king has unlimited power of life and death . . . in some tribes . . . he is almost worshiped." In Msambara the people say, "We are all slaves of the Zumbe (king), who is our Mulungu" (god). "By the state law of Dahomey, as at Benin, all men are slaves to the king, and most women are his wives"; and in Dahomey the king is called "the spirit." The Malagasy speak of the king as "our god"; and he is lord of the soil, owner of all property, and master of his subjects. Their time and services are at his command." In the Sandwich Islands the king, personating the god, utters oracular responses; and his power "extends over the property, liberty, and lives of his people." Various Asiatic rulers, whose titles ascribe to them divine descent and nature, stand in like relations to their peoples. In Siam "the king is master not only of the persons but really of the property of his subjects; he disposes of their labor and directs their movements at will." Of the Burmese we read, "Their goods likewise, and even their persons, are reputed his [the king's] property, and on this ground it is that he selects for his concubine any female that may chance to please his eye." In China "there is only one who possesses authority—the Emperor. . . . A wang, or king, has no hereditary possessions, and lives upon the salary vouchsafed by the Emperor. . . . He is the only possessor of the landed property."

Of course, where unlimited power is possessed by the political head—where, as victorious invader, his subjects lie at his mercy, or where, as divinely descended, his will may not be questioned without impiety, or where he unites the characters of conqueror and god—he naturally absorbs every kind of authority; he is at once military head, legislative head, judicial head, ecclesiastical head. The fully developed king is the supreme center of every social structure and the director of every social function.

In a small tribe it is practicable for the chief personally to discharge all the duties of his office. Besides leading the other warriors in battle, he has time enough to settle disputes, he can sacrifice to the ancestral ghost, he can keep the village in order, he can inflict punishment, he

can regulate trading transactions; for those governed by him are but few, and they lie within a narrow space. When he becomes the head of many united tribes, both the increased amount of business and the wider area covered by his subjects put difficulties in the way of exclusively personal administration. It becomes necessary for him to employ others for the purposes of gaining information, conveying commands, and seeing them executed; and, in course of time, the assistants thus employed become established heads of departments with deputed authorities.

While this development of governmental structures in one way increases the ruler's power, by enabling him to deal with more numerous affairs, it in another way decreases his power, for his actions are more and more modified by the instrumentalities through which they are effected. Those who watch the working of administrations, no matter of what kind, have forced upon them the truth that a head regulative agency is at once helped and hampered by its subordinate agencies. In a philanthropic association, a scientific society, or a club, those who govern find that the organized officialism which they have created often impedes, and not unfrequently defeats, their aims. Still more is it so with the immensely larger administrations of the state. Through deputies the ruler receives his information; by them his orders are executed; and, as fast as his connection with affairs becomes indirect, his control over affairs diminishes; until, in extreme cases, he either lapses into a puppet in the hands of his chief deputy or has his place usurped by him.

Strange as it seems, the two causes which conspire to give permanence to political headship, also, at a later stage, conspire to reduce the political head to an automaton, executing the wills of the agents he has created. In the first place, hereditary succession, when finally settled in some line of descent rigorously prescribed, involves that the possession of supreme power becomes independent of capacity for exercising it. The heir to a vacant throne may be, and often is, too young for discharging its duties; or he may be, and often is, too feeble in intellect, too deficient in energy, or too much occupied with the pleasures which his position offers in unlimited amounts; with the result that in the one case the regent, and in the other the chief minister, becomes the actual ruler. In the second place, that sacred character which he acquires from supposed divine ancestry makes him inaccessible to the ruled. All intercourse with him must be through the agents with whom he surrounds himself. Hence it becomes difficult or impossible for him to learn more than they choose him to know; and there follows inability to adapt his commands to the requirements, and inability to discover whether his commands have been fulfilled. His authority is consequently used to give effect to the purposes of his agents.

Even in so relatively simple a society as that of Tonga, we find an

example. There is an hereditary sacred chief who "was originally the sole chief, possessing temporal as well as spiritual power, and regarded as of divine origin," but who is now politically powerless. Abyssinia shows us something analogous. Holding no direct communication with his subjects, and having a sacredness such that even in council he sits unseen, the monarch is a mere dummy. In Gondar, one of the divisions of Abyssinia, the king must belong to the royal house of Solomon, but any one of the turbulent chiefs who has obtained ascendancy by force of arms becomes a Ras—a prime minister or real monarch; but he requires "a titular emperor to perform the indispensable ceremony of nominating a Ras," since the name, at least, of emperor "is deemed essential to render valid the title of Ras." The case of Thibet may be named as one in which the sacredness of the original political head is dissociated from the claim based on hereditary descent; for the Grand Lama, considered as "God the Father," incarnate afresh in each new occupant of the throne, does not receive his divine nature by natural descent, but, receiving it supernaturally, is discovered among the people at large by certain indications of his godhood; and with his divinity, involving disconnection with temporal matters, there goes absence of political power. A like state of things exists in Bootan. "The Dhurma Raja is looked upon by the Bootanese in the same light as the Grand Lama of Thibet is viewed by his subjects—namely, as a perpetual incarnation of the Deity, or Buddha himself in a corporeal form. During the interval between his death and reappearance, or, more properly speaking, until he has reached an age sufficiently mature to ascend his spiritual throne, the office of Dhurma Raja is filled by proxy from among the priesthood." And then along with this sacred ruler there coexists a secular one. Bootan "has two nominal heads, known to us and to the neighboring hill-tribes under the Hindoostanee names of the Dhurma and the Deb Rajas. . . . The former is the spiritual head, the latter the temporal one." Though in this case it is said that the temporal head has not great influence (probably because the priest-regent, whose celibacy prevents him from founding a line, stands in the way of unchecked assumption of power by the temporal head), still the existence of a temporal head implies a partial lapsing of political functions out of the hands of the original political head. But the most remarkable and at the same time most familiar example is that furnished by Japan. Here the supplanting of inherited authority by deputed authority is exemplified, not in the central government alone, but in the local governments. "Next to the prince and his family came the *karos* or 'elders.' Their office became hereditary, and, like the princes, they in many instances became effete. The business of what we may call the clan would thus fall into the hands of any clever man or set of men of the lower ranks, who, joining ability to daring and unscrupulousness, kept the princes and the *karos* out of

sight, but, surrounded with empty dignity and commanding the opinion of the bulk of the *samarai* or military class, wielded the real power themselves. They took care, however, to perform every act in the name of the *fainéants*, their lords, and thus we hear of . . . daimios, just as in the case of the Emperors, accomplishing deeds and carrying out policies of which they were perhaps wholly ignorant." This lapsing of political power into the hands of ministers was, in the case of the central government, doubly illustrated. Successors as they were of a god-descended conqueror whose rule was real, the Japanese Emperors gradually became only nominal rulers; partly because of the sacredness which separated them from the nation, and partly because of the early age at which the law of succession frequently enthroned them. Their deputies consequently gained predominance. The regency in the ninth century "became hereditary in the Fujiwara [sprung from the imperial house], and these regents ultimately became all-powerful. They obtained the privilege of opening all petitions addressed to the sovereign, and of presenting or rejecting them at their pleasure." And then, in course of time, this usurping agency had its own authority usurped in like manner. Again succession by fixed rule was rigorously adhered to; and again seclusion entailed loss of hold on affairs. "High descent was the only qualification for office, and unfitness for functions was not regarded in the choice of officials." Besides the Shôgun's four confidential officers, "no one else could approach him. Whatever might be the crimes committed at Kama Koura, it was impossible, through the intrigues of these favorites, to complain of them to the Shôgun." The result was that "subsequently this family . . . gave way to military commanders, who," however, often became instruments in the hands of other chiefs.

Though less definitely, this process was exemplified during early times in Europe. The Merovingian kings, to whom there clung a tradition of supernatural origin, and whose order of succession was so far settled that minors reigned, fell under the control of those who had become chief ministers. Long before Childeric the Merovingian family had ceased really to govern. "The treasures and the power of the kingdom had passed into the hands of the prefects of the palace, who were called 'mayors of the palace,' and to whom the supreme power really belonged. The prince was obliged to content himself with bearing the name of king, having flowing locks and a long beard, sitting on the chair of state, and representing the image of the monarch."

From the evolution standpoint we are thus enabled to discern the relative beneficence of institutions which, considered absolutely, are not beneficent, and are taught to approve as temporary that which, as permanent, we abhor. The evidence obliges us to admit that subjection to despotic rulers has been largely instrumental in advancing civilization. Induction and deduction alike prove this.

If, on the one hand, we group together those wandering, headless

hordes, belonging to different varieties of man, which are found here and there over the earth, they show us that, in the absence of political organization, little progress has taken place; and, if we contemplate those settled simple groups which have but nominal heads, we see that, though there is some development of the industrial arts and some coöperation, the degree of advance is but small. If, on the other hand, we glance at those ancient societies in which considerable heights of civilization were first reached, we see them under autocratic rule. In America purely personal government, restricted only by settled customs, characterized the Mexican, Central American, and Chibcha states; and in Peru the absolutism of the divine king was unqualified. In Africa, ancient Egypt exhibited in the most conspicuous manner this connection between despotic control and social evolution. Throughout the distant past it was repeatedly displayed in Asia, from the Accadian civilization downward, and the still extant civilizations of Siam, Burmah, China, and Japan reillustrate it. Early European societies, too, where not characterized by centralized despotism, were still characterized by diffused patriarchal despotism. Only among modern peoples, whose ancestors passed through the discipline given under this social form, and who have inherited its effects, is there arising an habitual dissociation of civilization from subjection to individual will.

The necessity there has been for absolutism is best seen on observing that, in the struggles for existence among societies, those have conquered which, other things equal, were the more subordinate to their chiefs and kings. And, since in early stages military subordination and social subordination go together, it results that, for a long time, the conquering societies continue to be the despotically governed societies. Such exceptions as histories appear to show us really prove the rule. In the conflict between Persia and Greece, the Greeks, but for a mere accident, would have been ruined by that division of councils which results from absence of subjection to a single head. And the habit of appointing a dictator, when in great danger from enemies, implies that the Romans had discovered that efficiency in war requires absoluteness of control.

So that, leaving open the question whether, in the absence of war, primitive groups could ever have developed into civilized nations, we conclude that, under such conditions as there have been, those struggles for existence, among societies which have gone on consolidating smaller into larger until great nations have been produced, necessitated the development of a social type characterized by personal rule of a stringent kind.

To make clear the genesis of this leading political institution, let us set down in brief the several influences which have conspired to effect it, and the several stages passed through.

In the rudest groups, resistance to the assumption of supremacy by any individual habitually prevents the establishment of settled headship, though some influence is commonly acquired by superiority of strength, or courage, or sagacity, or possessions, or the experience which accompanies age.

In such groups, and in tribes somewhat more advanced, two kinds of superiority conduce more than all others to predominance—that of the warrior and that of the medicine-man. Often separate, but sometimes united in the same person, and then greatly strengthening his hands, both these superiorities, tending to initiate political headship, continue thereafter to be important factors in the development of it.

At first, however, the supremacy acquired by a great natural power, or supposed supernatural power, or both, is transitory—ceases with the life of one who has acquired it. So long as the principle of efficiency alone operates, political headship does not become settled. It becomes settled only when there coöperates the principle of inheritance.

The custom of reckoning descent through females, which characterizes many rude societies and survives in others that have made considerable advances, is less favorable to establishment of permanent political headship than is the custom of reckoning descent through males; and, in sundry semi-civilized societies distinguished by permanent political headships, inheritance through males has been established in the ruling house, while inheritance through females survives in the society at large.

Beyond the fact that reckoning descent through males conduces to a more coherent family, to a greater culture of subordination, and to a more probable union of inherited position with inherited capacity, there is the more important fact that it fosters ancestor-worship and the consequent reënforcing of natural authority by supernatural authority. Development of the ghost-theory, leading as it does to special fear of the ghosts of powerful men, until, where many tribes have been welded together by a conqueror, his ghost acquires in tradition the preëminence of a god, produces two effects. In the first place, his descendant, ruling after him, is supposed to partake of his divine nature; and, in the second place, by propitiatory sacrifices to him, is supposed to obtain his aid. Rebellion hence comes to be regarded as alike wicked and hopeless.

The processes by which political headships are established repeat themselves at successively higher stages. In simple groups chieftainship is at first temporary—ceases with the war which initiated it. When simple groups that have acquired permanent political heads unite for military purposes, the general chieftainship is but temporary. As in simple groups chieftainship is at the outset habitually elective, and becomes hereditary at a later stage, so chieftainship of the compound group is at the outset habitually elective, and only later passes

into the hereditary. Similarly in some cases where a doubly compound society is formed. Further, this later-established power of a supreme ruler, at first given by election and presently growing hereditary, is commonly less than that of the local rulers in their own localities; and where it becomes greater it is usually by the help of ascribed divine descent or ascribed divine commission.

Where, in virtue of supposed supernatural origin or authority, the king has become absolute, and, owning both subjects and territory, exercises all powers, he is obliged by the multiplicity of his affairs to depute his powers. There follows a reactive restraint due to the political machinery he creates; and this machinery ever tends to become too strong for him. Especially where rigorous adhesion to the rule of inheritance brings incapables to the throne, or where ascribed divine nature causes inaccessibility save through agents, or where both causes conspire, power passes into the hands of deputies. The legitimate ruler becomes an automaton and his chief agent the real ruler, who, in some cases passing through parallel stages, himself becomes an automaton and his subordinates the rulers.

THE BLACK RACES OF OCEANICA.*

By Dr. R. VERNEAU.

NEGRO forms are figured among the earliest representations of men on ancient monuments. As early as the eighteenth dynasty (seventeen hundred years before the Christian era), the artists of Egypt represented at least five races of negroes. Nigritic types were also figured by the Greeks, Romans, Assyrians, Babylonians, and Persians, although none of those people had as extended knowledge of Africa as the Egyptians had. The examination of all the monuments which have come down from antiquity makes it evident that the negro races of Africa and Asia were well known. Scientific investigations of negro characteristics began to be made in the sixteenth century. The first to record one was Albert Dürer, who, in 1525, drew a profile of a negro inclosed in a system of lines, of which an oblique and an horizontal line formed at their junction a real facial angle. MM. de Quatrefages and Hamy, in their "Crania Ethnica," begin the study of the negro races with the negroes of Oceanica, and select as their point of departure the Negritos, the most brachycephalic race. The Negrito race proper, which was first observed in the Philippine Islands, has been found in the interior of the Peninsula of Malacca, the Sunda Islands, and the Andaman Islands. M. Hamy has been able to trace it even to the interior of India.

* Translated from the French by W. H. Larrabee.

The pure Negrito skull (Fig. 3) is sub-brachycephalic, having a mean index (cephalic, or horizontal) of 81·79; its capacity is from 1,310 to 1,535 cubic centimetres. The occipito-frontal curve is quite regular, and presents a depression over the forehead, another toward the third posterior of the sagittal suture, and an undulation at the level of the sinciput; passing the occipital protuberance, it turns sharply down-

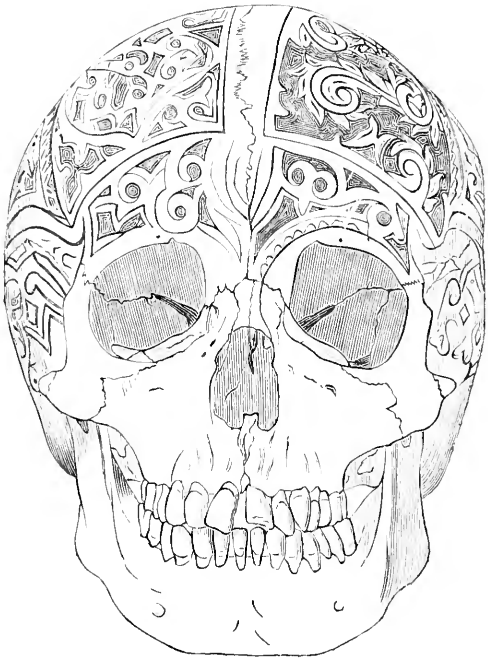


FIG. 1.—SKULL OF A NEGRITO OF BORNEO, CARVED BY THE DYAKS. (From the Museum of Lyons.)

ward. The frontal, narrow before, is well developed in the antero-posterior direction; the short length of the cranium corresponds with the shortness of the parietal and occipital bones.

In the face, the prominences of the brows are not very distinct, the space between the orbits is relatively considerable, the orbits are wide, almost square, the canine cavity is little marked, the prognathism is distinct in the middle alveolar region of the superior maxillary. The whole of the face is moderately elongated, showing a mean facial index of 67·17. The Mincopies, who live in the Andaman Islands, had already been studied by M. de Quatrefages, and his opinion that they almost exactly resemble the Aétas of the Philippine Islands is confirmed by the description of them in the "Crania Ethnica." The only difference is in a slightly higher elevation of the cranium, as is shown in the sketch.

Negritos whose history is fully described in this work are still liv-

ing in the mountains of India and Indo-China, and in the Malay Peninsula. The race is nearly extinct in the Sunda Islands, but it seems to appear again in Timor; and a head from that island, in the collection of the museum, reproduces, apart from some details of the facial bony structure, all the characteristics of the Mincopie heads. An elegantly carved skull from Borneo, belonging to the Museum of Lyons, also presents the same traits (Fig. 1).

The detailed examination of twelve skulls from the interior of New

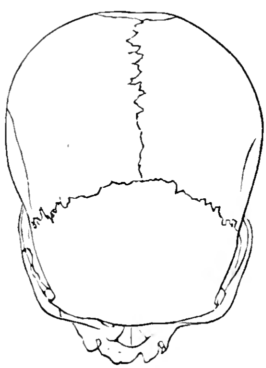


Fig. 2.—Skull of a Negrito of the Philippine Islands.

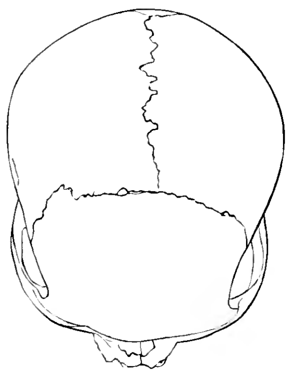


Fig. 3.—Skull of a Mincopie of the Andaman Islands.

Guinea, Rawak, Boni, the Island of Toud, and Amberbaki, has allowed the authors to recognize in those different points the existence of an intermediate race between the Negritos and the Papuans, which they have, therefore, designated as the Negrito-Papuan race. The skulls of this intermediate type (Fig. 4) are slightly elongated, with their mean index descending to 80·15, while the facial index rises to 67·17, and the maxillary prognathism is much more sharply defined than among the Negritos. Some of these heads have been artificially deformed.

The Negrito-Papuan race forms, in some respects, a transition between the Negritos proper and the Tasmanians. The description given of the last race, which is now extinct, is based on the study of numerous skulls in the collections of the Museums of Paris, London, Shelton, etc., and other authentic sources of information. The Tasmanians were differentiated from other oceanic negroes by a number of characteristics, and the study of their skulls enables us to make of them a special race, remarkably homogeneous, notwithstanding the differences which prevailed in the languages of the several tribes.

The index of the Tasmanian skull varied from 77·10 among the southern tribes to 76·34 among the northern tribes. Its mean capacity, 1,420 centimetres in men's skulls, was notably superior to that of negro skulls in general. It presented a special form, a kind of keel-shape,

which seemed to exist in all the adult Tasmanians, and which resulted from the disposition of the parietal bosses, they being very prominent, almost conical, and situated at an equal distance from the coronal and lambdoidal sutures. Between these prominences existed, on each side of the sagittal suture, itself placed in a hollow, an antero-posterior groove which contributed to give the skull its peculiar characteristic

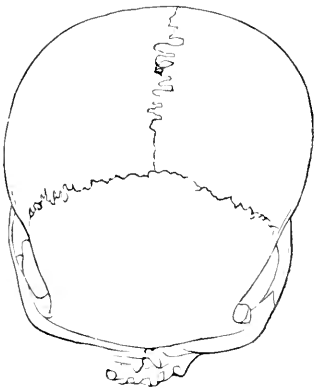


Fig. 4.—Skull of a Papuan Negrito of Rawak.

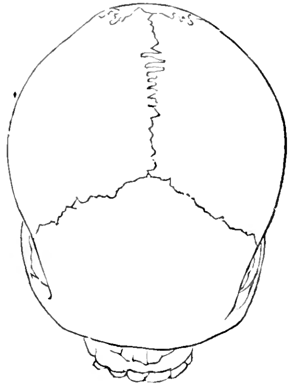


Fig. 5.—Skull of a Tasmanian.

form. It results from this considerable development of the parietal bosses that, below them, the figure of the skull was descending without swelling out, the maximum transverse diameter being nearly on a level with them. The antero-posterior curve was developed regularly to the occipital bone, which was very much swelled out, so that at this level the curve was slightly inflected upward ; at the summit of the occipital crest it was often abruptly inflected downward. The forehead was quite narrow. The face was not much raised, and exhibited brutal forms. The arches of the brows were prominent, and appeared more projecting than they were, on account of the sunken position of the root of the nose. The nasal bones, convex and pinched above, were deeply hollowed in their lower part, and were then lifted up to flatness in front. The very wide nasal orifice almost formed an equilateral triangle. The superior maxillary was notably prognathous, but the teeth, much less oblique than the bone, descended sometimes even vertically, and were of considerable size. The horizontal branch of the inferior maxillary was robust and thick, while the ascending branch was thin and narrow. The mandible was very short, so that the teeth had to be projected considerably forward to meet those of the superior maxillary. The chin was retreating.

The Malays gave the name of Papuans to the Oceanian negroes in general. The term, which signifies *frizzled*, is properly applied to the group who are distinguished by their bushy hair, and is now reserved for the race whose representatives are more or less numerously found

in nearly all of Melanesia and in part of Australia. The Papuan skull is plainly dolichocephalous; the index descends to 71·03, and even to 70·32 in the skulls of the men. The vertical diameter is at the same time considerable, and exceeds the maximum transverse diameter, so that the head is hypsistenocephalous, or higher than it is broad. The head which MM. de Quatrefages and Hamy have selected as typical of the race—a Mafor head from Port Dorei—(Fig. 6) has an horizontal index of 71·55, and a vertical index of 105·51, with a cranial capacity of about 1,350 cubic centimetres. It is long, narrow, and high. The lateral walls of the skull rise perpendicularly, in almost parallel lines, to the parietal bosses. At this point the transverse curve is directed obliquely toward the top of the head, where it becomes rounded, and forms, in connection with a kind of median crest which crosses the

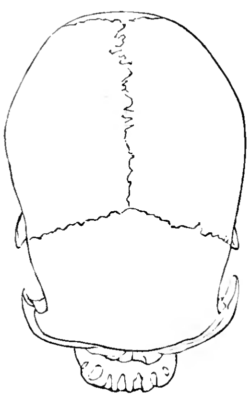


Fig. 6.—Skull of a Papuan Mafor.

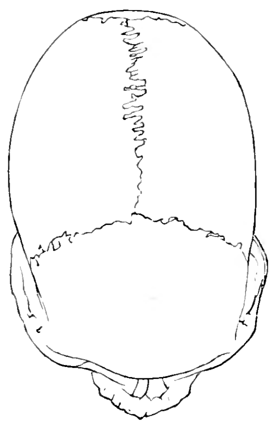


Fig. 7.—Skull from Arfak.

skull from front to rear, along the whole length of the sagittal suture, a large, blunt point. The forehead is narrow, causing the cheek-bones to appear very prominent, although their lateral development is not, really, at all exaggerated. As a whole, the face is high and narrow. The bones of the nose are quite long and slightly concave, the cavities and prominences of the lower part of the superior maxillary are not clearly defined. The prognathism of this race is so sharp that in the *norma verticalis* the alveolar border and a part of the bones above project in front of the skull. The facial angle of Camper varies between 73° and 76°. The Papuan woman is generally less dolichocephalous and hypsistenocephalous than the man.

Pure or more or less mixed Papuans are found in Ternate, Ceram, and Timor, in Malaysia. The pure type occurs in New Britain, and at Vanikoro in the New Hebrides, but in other parts of Melanesia it is mixed with the Negrito-Papuan or the Polynesian type. Traces of the former mixture may be detected in the Island of Toud, although

the greater part of the inhabitants of that island are real Papuans, and even in New Guinea.

The Polynesian type may be perceived in the Louisiade Archipelago and in all eastern Melanesia, beginning at the Solomon Islands. In some of the islands it is almost pure. The Papuan-Polynesians, concerning which we have the most information, are those of the Loyalty and Feejee Islands and New Caledonia. The Papuan type is occasionally found pure in those groups, but is most frequently mixed with the Polynesian, and in these cases the mixture is accentuated by marked phenomena. The heads of the half-breeds are less dolicho-

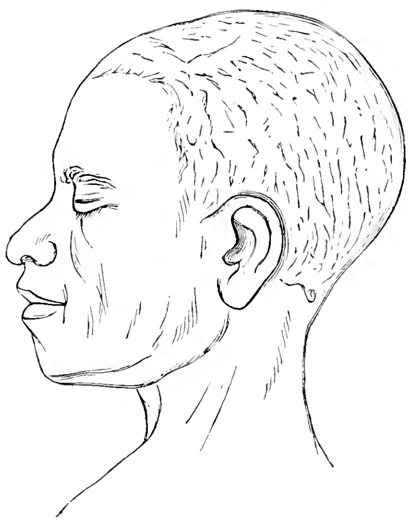


Fig. 8.—Bust of a Native of New Guinea.

cephalous and less hypsistenocephalous than Papuan heads, without reaching the Polynesian proportions. The modifications in the face are more complicated. Papuans are found at the extremities of Polynesia, as far north as the Sandwich Islands, as far south as New Zealand, and as far east as Easter Island, where they have been carried by voluntary or accidental migrations, or in slavery. They also occur erratically in some islands of Micronesia, particularly the Caroline Islands and in Rawak.

The Australian skulls in the European museums appear to arrange themselves into two homogeneous series, which do not, however, indicate a distinction of race, as M. Topinard believes, but seem to be determined by differences of sex. The man differs more from the woman in this than in any other race. There are, however, other races than the Australian in New Holland, as sporadic Melanesians and Indonesians ; but, laying aside these casual cases and a few exceptional

cases in Queensland and southern Australia, it may be said that Australian skulls of the same sex are alike, and that those of the interior populations differ from those of natives of the coast only in a little greater development, corresponding with their larger stature. This superiority is the result of better conditions of existence. It is enough, therefore, to describe two types: the Australian type proper, to which

FIG. 9.—BUST OF AN ISLANDER OF TOUD (TORRES STRAITS).

most of the known tribes belong; and the *Neanderthaloid* type, found only among a few southern tribes, the most of which are in process of extinction.

The head which has been selected as a type of the former race is that of an individual from Port Essington. It has a cranial capacity of only 1,250 cubic centimetres, while the average of Australian skulls is 1,285 cubic centimetres, and is very dolichocephalous and hypsistenocephalous—that is, is elongated from front to rear, and is higher than broad. The indices are horizontal 67·21, vertical 105·69. The prominences of the brows are voluminous, as is also the glabella, which appears to be prolonged over the forehead. The medial prominence of the forehead is quite marked, the lateral ones are nearly effaced. The parietals present an analogous disposition: their inner borders rise along the sagittal suture so as to form a kind of roof, while the bosses are hardly indicated. The curved lines on the occipital form thick and prominent puffs; the bone is flattened over the cerebellum, and presents well-defined muscular impressions. The antero-posterior curve is regular to near the lambdoidal suture, whence it rises to the occipi-

tal. The most marked characters in the face are the thickness of the external orbital processes, the forward projection of the cheek-bones, the depression of the root of the nose, the shortness and breadth of the nose, and the mode of termination of the bridge of the nose, which, instead of forming an angle, is prolonged into a kind of a gutter. The jaws are narrow and the branches of the dental arch tend to be parallel. The palatal vault is deep; and the prognathism is very

Fig. 10.—Bust of a Tasmanian.

great, the mean alveolar facial angle being 64°, but the massive teeth are less oblique than the alveolar part.

In the women the prominences of the brows nearly disappear, while the parietal bosses are more accentuated. The forehead and the lower occipital bone are more swollen; the antero-posterior curve is relatively depressed, although the skull continues to show the form of a roof. The prognathism of the face is more marked, and the teeth are more inclined than in the men.

The second Australian type, the dolichoplatycephalic or Neanderthaloid type, although it is less widely diffused than the other, is nevertheless of very great interest to anthropologists. In it there exist, as Huxley has already remarked, individuals and even a whole race, although it is disappearing, that present the cranial forms of which the Neanderthal man affords the most pronounced example. We are

not, then, authorized to believe that the Neanderthal skull was one of an idiot, or of any exceptional being not possessing the ethnic characters of the race which lived at the same epoch with him. If there still exists a race offering the same characteristics, there is no reason why that race may not have existed in a geological age anterior to our own. The Australian skull of the Neanderthaloid type, which is found, ac-

Fig. 2.—Bust of a Tasmanian.

cording to Huxley, in Queensland, is also met as an erratic in New South Wales. But a tribe, seeming to belong entirely to the race under consideration, lived only in the environs of Adelaide; and the seven pieces from which the studies of the type were made are from that locality.

MM. de Quatrefages and Hamy conclude their study of the Australian race with an enumeration of the cranial characteristics which distinguish the Papuans from the Australians, and a comparison of those races with the Dravidian races of the interior of India. Common characteristics appear in both groups, and resemblances may be traced between the Australian and Dravidian languages. The evidence, however, is still too slight to permit us to assign a common origin to the races of New Holland and the black races of India.—*La Nature.*

PHYSICAL EDUCATION.

By FELIX L. OSWALD, M. D.

OUT-DOOR LIFE.

"Disease is a hot-house plant."—Haller.

EVERY disease is a protest of Nature against an active or passive violation of her laws. But that protest follows rarely upon a first transgression, never upon trifles; and life-long sufferings—the effects of an incurable injury excepted—generally imply that the sufferer's mode of life is habitually unnatural in more than one respect. For there is such a thing as vicarious atonement in pathology: a strict observance of any one of the three or four principal health-laws rarely fails to reward itself by a long immunity from the consequences of otherwise evil habits. Frugality thus counteracts the morbific tendency of indolence; perfect continence may steel even a feeble constitution against the effects of hunger and overwork; and, by avoiding the great vice of intemperance, the Epicureans atoned for a multitude of minor sins.

But the surest of all natural prophylactics is active exercise in the open air. Air is a part of our daily food and by far the most important part. A man can live on seven meals a week, and survive the warmest summer day with seven draughts of fresh water, but his supply of gaseous nourishment has to be renewed at least fourteen thousand times in the twenty-four hours. Every breath we draw is a draught of fresh oxygen, every emission of breath is an evacuation of gaseous recrements. The purity of our blood depends chiefly on the purity of the air we breathe, for in the laboratory of the lungs the atmospheric air is brought into contact at each respiration with the fluids of the venous and arterial systems, which absorb it and circulate it through the whole body; in other words, if a man breathes the vitiated atmosphere of a factory all day and of a close bedroom all night, his life-blood is tainted fourteen thousand times in the course of the twenty-four hours with foul vapors, dust, and noxious exhalations. We need not wonder, then, that ill-ventilated dwellings aggravate the evils of so many diseases, nor that pure air should be almost a panacea.

Out-door life is both a remedy and a preventive of all known disorders of the respiratory organs; consumption, in all but the last stage of the *deliquium*, can be conquered by transferring the battle-ground from the sick-room to the wilderness of the next mountain-range. Asthma, catarrh, and tubercular phthisis, are unknown among the nomads of the intertropical deserts, as well as among the homeless hunters of our Northwestern Territories. Hunters and herders, who breathe the pure air of the South American pampas, subsist for years

on a diet that would endanger the life of a city dweller in a single month. It has been repeatedly observed that individuals who attained to an extreme old age were generally poor peasants whose avocations required daily labor in the open air, though their habits differed in almost every other respect; also that the average duration of life in various countries of the Old World depends not so much on climatic peculiarities or their respective degree of culture as on the chief occupation of the inhabitants; the starved Hindoo outlives the well-fed Parsee merchant, the unkempt Bulgarian enjoys an average longevity of forty-two years to the west Austrian citizen's thirty-five.

In the cities of the higher latitudes, sedentary occupations in a vitiated atmosphere become often a sort of "second nature": artisans and shopkeepers, after following their business for a number of years, frequently come to dislike fresh air, as the convent slave, by an analogous suppression of his better instincts, becomes averse to free inquiry. But this abnormal indolence seldom becomes hereditary—perhaps never, if we except the children of inebriate idiots. The mediæval prejudice against all natural propensities—founded on the dogma of innate depravity—is, indeed, strikingly refuted by a young child's love of out-door exercise. Without the mediation of supernatural revelators or preternatural bugbears, a healthy boy prefers even the hardships of our northern winter sports to the atmosphere of a comfortable stove-room, and in summer-time the paradise of childhood is still a tree-garden. No domestic events of our later years can efface the impression of the woodland rambles, butterfly hunts, and huckleberry expeditions of our boyhood: the recollections of our first out-door adventures endure like the mountains and rivers of a promised land whose cities have vanished for ever.

I have often been asked at what age infants can first be safely exposed to the influence of the open air. My answer is, On the first warm, dry day. There is no reason why a new-born child should not sleep as soundly under the canopy of a garden-tree on a pillow of sun-warmed hay as in the atmosphere of an ill-ventilated nursery. Thousands of sickly nurslings, pining away in the slums of our manufacturing towns, might be saved by an occasional *sun-bath*. Aside from its warmth and its chemical influence on vegetal oxygen, sunlight exercises upon certain organisms a vitalizing influence which science has not yet quite explained, but whose effect is illustrated by the contrast between the weeds of a shady grove and those of the sunlit fields, between the rank grass of a deep valley and the aromatic herbage of a mountain meadow, as well as by the peculiar wholesome appearance of a "sunburned" person or a sun-ripened fruit. Sunlight is too cheap to become a fashionable remedy, but its hygienic influence can hardly be overrated. Even in the glorious climate of the Latian hills, the Roman Epicureans constructed special *solaria*—glass-covered turrets—where they could bask in the full rays of the winter

sun, the balm of old age, as Columella calls it; and, on the summerless Isle of Rügen, Nature has taught the poor fishermen to carry their bairns to the downs of Stubbenkammer, whenever the Baltic fogs alternate with a few sunny days. Dry sand is, indeed, an excellent medium of solar caloric. Children like it instinctively; most babies are fond of rummaging in some tangible, yielding element. In default of a sunny beach, get a car-load of river-sand, spread it and expose it to the sun for a couple of hours, then rake it together, mix it *ad captandum* with a bushel of pebbles (good-sized ones, lest they might be mistaken for sugar-plums), divest your *bambino* of all superfluous clothing, and let him wallow—all afternoon, if he chooses; if the surface of the pile gets too warm, instinct will teach him to dig down to the cooler substrata. Or take him to a meadow where fresh hay has been piled up in little stacks; climbing and tumbling will do him more good than lying motionless in a narrow baby-carriage. The inventor of the Kindergarten recommends a grassy hollow with scattered playthings, piles of dry leaves, etc. (near a shade-tree in midsummer), where young squealers can take care of themselves for an hour or two, and warrants that they will not cry, unless their botanic researches should happen to acquaint them with the properties of the German horse-nettle. On mild winter days, too, self-motive babies ought to pass a few hours out of doors, even if the ground be a little wet; a sunny nook on the lee-side of a garden-wall is a healthier playground than the dusty floor of a stove-room.

From the fourth to the end of the fourteenth year children should spend the larger part of every summer in out-door exercises. Next to a total reform of our dietetic habits, a general observance of this rule would be the surest way to regain the hardiness and longevity of our forefathers. The years of growth lay the foundation of our bodily constitution, and, under favorable circumstances, the human system, during that period, seems to accumulate a surplus of physical vigor, which in after-life will become available as an annuity-fund of health and happiness. Education, like charity, ought to begin at home; in boarding-colleges, protectories, orphan asylums, etc., the rudiments should be taught in *winter schools.* At the price of life-long infirmities precocious erudition is too dear-bought; besides, it should not be forgotten that in the years when students can take a personal interest in their lessons they will make more progress in a single month than during years of involuntary confinement in boy-pens, as Dr. Salzmann calls our municipal baby-schools. The employment of young children in cotton-factories is a crime against society, and ought to be legally prohibited, like the trade in Italian organ-boys and Chinese slave-girls. Swiss artisans, who have passed their boyhood in the mountains, are comparatively proof against the influence of in-door occupations. And, in the mean time, out-door life need not be a life of idleness. That children are fond of play means simply that they pre-

fer entertaining employments to tedious ones. Youngsters under five years gambol instinctively like young puppies, in order to acquire the art of locomotion, but soon afterward they begin to play with a conscious purpose, and do not object to playing at something profitable; young savages and peasant-boys join in the labors of their parents with an eagerness that vindicates human nature against the charge of innate frivolity. Make your boy a Jack-of-all-out-door-trades before you make him a classic polyglot, and, if you destine him for any trade in special, let him play with the tools of that special trade. "The best plan of education," says Goethe, "is that of the Hydriotes, the Greek trading-sailors, who take their infant boys out to sea and let them sport around amid oakum and belaying-pins before they learn to handle them with a business purpose. Such a school has graduated the heroes who with their own hands could grapple the fire-boat to the flag-ship of the enemy."

Even for their children's sake, married men should never quarter their families in the heart of a great city. Not everybody can own a farm, but, wherever the suburban cottages adjoin waste building-lots and dry ravines, there will be no lack of opportunities for out-door pastimes. Let the girls make weed-brooms, and the boys construct fortifications, *à la* Uncle Toby, if they can do no better, and miss no chance to send them out in the country for a day or two. Our town parks are too exclusive; sauntering between inviolate grass-plots and prohibitory placards is dull work for urchins that long to commit horse-play; but there are few cities, even on the Atlantic seaboard, where the "open country"—woods, fallow fields, and hillsides—could not be reached by a two hours' walk. There let your children spend every sunny afternoon; make arrangements with your neighbors, and engage a guide if you can not afford to go yourself; teach the youngsters to collect beetles and butterflies, encourage the fern mania if your girl has outgrown the buttercup period, connive at a bird's nest or two, do anything to keep them out of the tenement dungeons. If you are blessed with a farm (or a tolerant country cousin), haymaking, apple-gathering, turkey-herding, repairing of ditches and garden-walls, will make earth an Elysium to every normal child; never mind the weather; a summer shower, a chilly morning, or a hot afternoon will not hurt a healthy boy, and the girls will take care of themselves—or rather of their dress—if the grass is wet. If you send them to school before their teens, give them at least the full benefit of their vacations and of every free Saturday. In fall and winter a day of athletic field-sports will keep a boy in tolerable health for the rest of the week, and a vacation tour of six or eight weeks may atone for many months of sedentary life.

In the preceding chapter I have pointed out the main cause of catarrhal affections. With the exception of deep-seated breast-coughs, "colds" may be nipped in the bud by a few hours of hard, *sudorific*

work in the open air. It may be an heroic cure, requiring a good deal of will-force in cold weather, but it is an infallible and the only radical remedy. In half a day the nasal ducts and the perspiratory exhalants will throw off irritating matters which would defy the drug-doctor for a couple of weeks, or yield only to exercise their influence in another direction, for poison-remedies merely change the form of a disease. But the beneficial effect of out-door exercise is not limited to the respiratory organs: their quickened function reacts on the digestive apparatus, on the nervous system, and through the nerves on the mind; true mental and physical vigor in any form can be maintained only on a liberal allowance of life-air; those who feed their lungs on miasma become strangers to that exuberant health which makes bare existence a luxury. After years of in-door life the victims of melancholy, dyspepsia, and dull headaches come to accept their discomforts as the normal condition of mankind, but upon the first appearance of such disorders our instinct suggests the cause and the cure with an urgency which makes confinement in the atmosphere of our northern dwelling-houses the greatest affliction of childhood. If we reflect on the fact that our earth is surrounded by a respirable atmosphere of at least eight hundred million cubic miles, it seems a sad comment on the enlightenment of modern civilization that the unsatisfied thirst after life-air should inflict more misery upon millions of our fellow-men than hunger and all the hardships of poverty combined. "On the day of judgment," says Jean Paul, "God will perhaps pardon you for starving your children when bread was so dear; but, if he should charge you with *stinting them in his free air*, what answer shall you make?"

Perfect health depends upon a daily supply of fresh air as much as on our daily bread; but within certain limits the human organism is capable of adapting itself to abnormal circumstances. A man may accustom himself to devour his weekly allowance of solid food at a single meal, and in a similar way the vitalizing elements of air and sunshine can be hoarded up—allotropically, for all we know—for days, weeks, and months in advance. The Zooloo hunter who, after a six days' fast, gets a chance to satisfy the cravings of his stomach, can not be expected to content himself with half-pint rations *à la* Luigi Cornaro, and in midsummer, after six months of sedentary life, a boy should get his fill of out-door exercises; let him drink sunlight at every pore, do not stint his allowance of oxygen, compensate him for long arrears of woodland air and mountain-rambles.

With a little experience vacation trips can be managed very cheaply. Professor Jordan, of the Ilefeld *Pedagogium*, takes his summer boarders to the Hartz, or even to the Austrian Alps, at an aggregate daily expense of fifteen marks (three and a half dollars) for twenty or twenty-five big boys with North-German appetites. They carry their own beds in the form of a plaid and a pair of foot-sacks (boot-

like felt socks), and sleep wherever they find a shade-tree or an open barn. Their portable commissariat consists of biscuits and brown sugar; with fresh milk and such *entremets* as the mountain inns may afford, they make out two good meals a day, besides occasional luncheons of nuts and huckleberries. Twenty-two of the twenty-four hours are thus spent in the open air, but the long summer days are almost too short for all the entertainments on the liberal professor's programme. Zoölogy, botany, and geology are only collateral pursuits, the main thing is the uproarious fun in the mountains; climbing cliffs, tumbling bowlders from projecting rocks, and chasing squirrels from tree to tree do not endanger the toilet of the excursionists, for every one of them wears *turner-drell*, a sort of coarse linen, as tough, though not quite as soft, as corduroy.

Observant managers of such expeditions soon get rid of the dismal prejudices against cold spring-water, "wet feet," and "untimely baths." The craving of a thirsty wanderer after cold water is not an abnormal appetency, but a natural instinct, and can be indulged with perfect impunity; a bath in sun-warmed river-water is healthy as long as it is enjoyable; South-Sea Islanders and the children of the Genoese fishermen spend whole afternoons in the surf, and—barring sharks and medusas—without fear of dangerous consequences. There is no harm in wet stockings as long as the feet are in motion; at home it is perhaps better to change them at once, though the Canadian lumbermen dry them on their legs before the camp-fire, or even in bed—i. e., under a pair of "Mackinaw blankets," which blankets have often served as overcoats during the day, but in the course of the night are dried by the animal warmth like a pack of wet sheets. Sunstrokes can be obviated by a simple and very inexpensive precaution—temporary abstinence from animal food. A refrigerating diet (vegetables, fruit, etc.) counteracts the effect of a high atmospheric temperature, but the calorific influence of meat and fat, combined with solar heat and bodily exertion, overcomes the organic power of resistance, the pyretic blood-changes produce congestion of the brain and sometimes instant death. I venture the assertion that in nineteen out of twenty cases of comatose sunstroke it will be found that the victims were persons who had gone to work in the hot sun after a meal of greasy viands. One to two P. M. is the sunstroke-hour.

Among the permanent benefits which young persons may derive from a pedestrian tour, it is not the least that they will mostly get rid of the night-air superstition. Sweet rest and pleasant dreams he knows not who has never slept under a Mexican live-oak tree on a bundle of fresh-plucked Spanish moss, or in the loft of a Tennessee cotton-gin while the winds of the summer night play in draughts and counter-draughts through four open louvres. The advantages of a hardy education in all such things are quite incalculable; the word *hardiness* sums up the chief characteristics that distinguished the

moral and physical life of the ante-Christian ages from the scrofulous effeminacy of our stove-room civilization.

The teachers of the *Pedagogium* and similar institutions assured me that their scholars were never more *aufgeweckt* (wide-awake) than during the first six or eight weeks after the long vacations; even the drawing-masters had no reason to complain about "club-fists." It is a very common but quite erroneous notion that the burly strength of the human hand impairs its capacity for delicate manipulations: the iron-fisted Gemsen-jäger of the Tyrolese Alps are the nicest marksmen; and Leonardo da Vinci, who could draw a perfect circle without a compass, could not the less break a silver piaster between his two thumbs and two forefingers.

The Ilefelders were also the first to make Saturday an hygienic sabbath. In spring and fall, all such Saturdays should be consecrate to the wood-gods; leaf-forests, under the influence of sunlight, exhale the antidote of our atmospheric poisons. Start the youngsters at sunrise with a basketful of cold meats, and orders for an equal quantity of strawberries, or, if the woods are safe, let them go on Friday night, and camp in the open air; they will long for the advent of that night as Tom-a-lin for the festival of the fairies. Let them rise with the sun and spend the whole day in active exercise, the merrier the better; in a mountain country arrange a new programme for every week, explore the local Ararats, and let the boys scale them in succession, as the members of the Alpine Club tackle their bergs and horns. If the weather should disappoint you, do not hesitate to *improve* the next sunny day, though it should happen to be a Sunday. The God of Nature can be worshiped in his own temple: the wonder of his living world is his most authentic revelation. Where Sunday is the only free day in the week, no puritanical tyranny or Jesuitical ingenuity will ever prevent the poor from making it a day of recreation; the only question is, whether that recreation shall be sought in the secret rumshops and back-alleys of the city, whose gates the sabbatarians would shut upon us, or in the free woods and mountains, where the worshiper of the All-Father can find inspiration as well as joy and health. The wood-thrush, it is true, does not modulate her anthems in a whining drawl; the pine-tree lifts his head without fear of provoking his Creator by a want of crawling humility; no dread of a joy-hating priest-god disturbs the gambols of the squirrel and the aërial dances of the brook-midge; the butterfly and the humming-bird do not think it necessary to "mortify the eye with dreary drab," but their happiness imparts a lesson not less divine for being at variance with the doctrines of an atrabilious fanatic.

According to the Grecian allegory, the wood-craft goddess Diana was the antagonist of the Cyprian Venus; and a *penchant* for out-door sports is indeed the best safeguard against certain vices of youth. The precocious Don Juans of our great cities could be more easily re-

formed by a hunting expedition to the next Sierra Nevada than by all the homilies of Fray Gerundio. Like depraved humors, prurient propensities yield to active exercise more readily than to physic and prayer. Hunting tribes are generally continent, stalwart, and comely; wood air is a cosmetic; the finest types of the human form are not found within the precincts of the Palais Royal, but in the Caucasus and the Kentucky forest counties.

Enjoyable winter excursions are a privilege of the rich; still, a pair of good skates make a convenient pond or a small river a great blessing. From a sanitary point of view, the neighborhood of larger streams is not so much of an advantage; besides being the terror of parents during the skating season, a big river is apt to render the contiguous lowlands more or less malarious, especially after every inundation. In snow-bound villages children have to depend mainly on in-door exercises; cold air, however, is a powerful tonic, and a two hours' snowball-fight will generally suffice to vitalize a juvenile constitution for a couple of days. Mountain air, too, is a peptic stimulant, and pedestrian excursions are doubly invigorating if they include a good deal of up-hill work.

For those who wish to select their dwelling-place with regard to the hygienic interest of their children, the best location is, therefore, on the whole, the bank of a small river in the neighborhood of a large mountain-range.

HISTORY OF CHRONOLOGY.

By Professor E. S. BURNS.

CHRONOLOGY is the science of the measurement of time, of ascertaining and fixing dates, which constitute the landmarks by which the mind is guided in its backward course through the long vista of years, and enabled to locate and fix the events of history, the knowledge of which would otherwise be a confused and wellnigh useless attainment. The advanced state of astronomical science and the experience of those who have gone before us have enabled us to reduce all that pertains to this subject to so complete a system that we lose sight of its magnitude and importance; we forget the slow progress and toilsome research which the great minds of past centuries had to undergo to reach the present state of correctness. To appreciate even faintly this magnitude, we must transport ourselves backward a few thousand years, and forget, if we can, the improvements of modern astronomy, the developments of mathematics, and, above all, the universality and ubiquity of modern almanacs.

The first and most obvious division of time is the day—the time required for a revolution of the earth upon its axis—which could not

have been a very difficult matter to ascertain with sufficient correctness. But to mark and fix the time of the sun's apparent revolution through the heavens among the stars was a matter of so great difficulty that it was not exactly ascertained even at the time of the reformation of the calendar in 1582; yet so uniform is the motion of the earth in its orbit that the results of modern experiments render it next to absolutely certain that the time of orbital revolution has never varied even the fraction of a second. In the infancy of astronomy, many ingenious expedients were adopted to ascertain this and other matters connected with the times and motions of the planets and other heavenly bodies, one of which may be mentioned even at the risk of tediousness. To ascertain the exact time of the revolution of the concave of the heavens, two vessels were placed over each other, the upper filled with water, the lower empty. At the moment of the appearing of a certain star above the horizon, the water was permitted to flow from the upper into the lower vessel, and the flow was continued until the same star appeared the next night, when the flow was stopped. The whole concave of the heavens had then made one revolution. The water which had flowed out during this time was then divided into twelve equal parts, and smaller vessels were made each to hold just one of those parts, and on the following evening they repeated the operation, filling successively six of those vessels, and noting carefully what stars rose above the horizon during the time required to fill each of them. Each group of stars which rose during the time of filling one small vessel was called a *station* or *house* of the sun. They then postponed operations upon the other half of the heavens for six months, when they repeated it, and thus divided the path of the sun through the whole heavens into twelve divisions, to most of which they gave the names of certain animals: hence the term *zodiac*, the propriety of which could have been seen only by the fertile fancies of the childhood of the race. The whole ancient method of dividing and naming the constellations is to us utterly absurd, and is really a hindrance to a knowledge of the stars. Fanciful forms of snakes and dogs and lions and bulls and wagons and scorpions convey to us no idea but one of confusion and perplexity, and they are tolerated for the same reasons that we tolerate our bungling orthography: we are loath to break away from the associations of antiquity; we are loath to sever the giant strides of Science, in its strength and manhood, from the feeble totterings of its infancy.

The time required by the sun to pass through one of these groups or signs is nearly equal to a lunar month; the time required to pass through three of them was called a season, as we have it now. All this was done by the Chaldeans or Egyptians, centuries before Greece or Rome had inhabitants or a name.

The Greeks divided the year into twelve lunar months, but, as this lunar year differed from the true year by about eleven days, they cor-

rected the error, after many other devices, by intercalating three months every eight years, making every eighth year consist of fifteen months—a method used by them for many years, perhaps centuries. It is said, however, that the length of the year was known, as early as the time of Solon, to be three hundred and sixty-five and one quarter days. Prior to the time of Numa, the Roman year consisted of ten months. He divided it into twelve lunar months, and to correct the error of eleven days a month was intercalated every second year. The management of this matter was intrusted to the priests, who added days whenever they deemed them necessary. But, owing to their ignorance of astronomy, this method proved irregular and erroneous, and the winter months were gradually carried back into autumn, the autumn months into summer, etc.

These errors had become so troublesome in the time of Julius Cæsar that he undertook, with the aid of an eminent astronomer (Sosigenes), to correct the calendar, which was done as follows: The Roman civil year had lost about ninety days. These were added to the year of three hundred and fifty-five days, making that year consist of four hundred and forty-five days, which is known in history as the "year of confusion." The year henceforward was made to consist of three hundred and sixty-five days, by adding ten days distributively to as many months. The odd quarter of a day was not noted until every fourth year, when the sum of these fourths made one day, and that year consisted of three hundred and sixty-six days. This odd day was inserted after the sixth day before the kalends of March, i. e., after the 24th of February, and was not counted as an addition to the year, but as a sort of appendix. Hence the sixth of the kalends of March was called bissextus, or double sixth, which root is still retained in our word bissextile, though the day is now added at the *end* of February. This arrangement would have been entirely correct had the year consisted of exactly three hundred and sixty-five and one quarter days. It was, however, in course of time, discovered to be erroneous, and another correction was made, which we will consider by and by. This new system went into effect on January 1, 46 B. C.

The subdivisions of the Roman month were apparently arbitrary. The days were not numbered as we have them, but the first day of every month was called the *calends*, the fifth the *nones*, and the thirteenth the *ides*, except in the months of March, May, July, and October, when the nones fell on the seventh and the ides on the fifteenth. From these points the days were counted backward—i. e., the last of February was called Prid., Kal., Mar., etc.

NAMES OF MONTHS.—The division of days into weeks was invented at a very early day by the Chaldeans, and was afterward adopted by almost all civilized nations, and by the Romans about the third century A. C. The principle upon which the days were named is odd enough to deserve especial notice. The order of the planets, according to the

Ptolemaic system, was: 1. Saturn; 2. Jupiter; 3. Mars; 4. Sun; 5. Venus; 6. Mercury; 7. Moon. The Chaldeans called the twenty-four hours of the day by the names of these planets in their order, and named each day from the first hour of the day. Thus, first hour of first day was Saturn; last hour (or twenty-fourth) was Mars; first hour of next day was Sun, hence called Sunday; first hour of next day Moon, hence called Monday, etc. Our Saxon ancestors named the days from their corresponding gods. Thus, what the Romans called Mars-day, the Saxons called Tuisco-day (whence Tuesday), Tuisco being their god of war as Mars was among the Romans, and so of the rest.

The early Romans began the year with March, but in the time of Cæsar it began with January. The early Christian Church began it on March 25th, and this was the beginning of the civil and ecclesiastical year in England and her American colonies until 1752, when it was changed by act of Parliament to January 1st.

Cycles.—To facilitate computation of time, to fix the recurrence of moons and days, and to establish epochs as standpoints of chronology, recourse was had to cycles, which we will now examine. The word *cycle* is derived from a Greek word which signifies a circle—here it signifies a circle of time. The first and most important among them was the Cycle of the Moon, the object of which was to accommodate the computation of time by the moon to that of the sun. It was invented about 430 B. C., by an Athenian named Meton, whence it was called also the Metonic Cycle, and was used to fix the times of the Grecian festivals, but fell into disuse with these festivals and was afterward restored by the Council of Nice, A. D. 325, being best adapted of all to fixing the time of Easter.

This cycle, at the time of its invention, was deemed entirely correct, and was so much superior to any other that had been attempted that each year was written in letters of gold in the public marts of Greece, from which cause it has ever since been known as the "golden number." It was constructed as follows: It had been discovered that the lunar year was eleven days shorter than the solar year; so that, if a new moon occurred upon any given day of any solar year, on the same day of the next solar year the moon would be eleven days old, on the same day of the second year twenty-two days old, etc. Examination showed that the new moon would again occur upon the same day of the solar year in the course of nineteen years. Hence the lunar cycle consists of nineteen years. The other ancient cycles are unimportant for our present purpose; the other cycles that we shall consider are the inventions of modern chronologers.

Solar Cycle.—Chronologers have affixed to the seven days of the week the first seven letters of the alphabet, as follows: To January 1, A; January 2, B, etc., and whichever letter the first Sunday of the year happens to fall upon is called the dominical or Sunday letter for that year. The object of this cycle is to find (without reference to the

almanac) what day of the week corresponds to any day of any month of any year, and it is constructed in this manner.

As every common year consists of fifty-two weeks and one day, supposing the 1st of January of any year to fall upon Sunday, A will be the Sunday letter for that year. The last day of that year will also be Sunday, and Monday will be the 1st of January of next year; and, as A is always affixed to the first day of the year, G will become the Sunday letter for that year. The next year will begin with Tuesday, which will make its Sunday letter F, etc.; hence, if there were no leap-year, the Sunday letter of each succeeding year would be removed one letter further backward, and in seven years the cycle would be complete, and the Sunday letter of the eighth year would again be A. But, as every leap-year has fifty-two weeks and two days, the letter C, which always belongs to the 28th of February, is also affixed to the 29th, which puts the Sunday letter for the remainder of the year one letter further back. Leap-year has therefore two Sunday letters instead of one, as in common years. This change takes place every four years; the other, as we have seen, would take place in seven years. Hence a complete cycle of the Sunday letter consists of the multiple of seven and four = twenty-eight years; i. e., in any given century, the Sunday letters will again follow each other in exactly the same order every twenty-eight years.

Indiction Cycle.—This is a cycle of fifteen years established by the Emperor Constantine, at the termination of which a tax was levied to pay the soldiers whose term of enlistment was fifteen years. It was afterward ordered by the Council of Nice that this cycle, beginning A. D. 312, should be substituted as the epoch from which all dates should be reckoned instead of that of the Olympiads, which, until that time, seems still to have been used in the Eastern Empire of the Romans.

The epoch from which we now compute years—i. e., the birth of Christ—was not used until about the year 500. The universal adoption of this by all Christendom has obviated the necessity of many of the cycles and epochs used prior to that time, and it is impossible for us now to estimate the difficulties the earlier chronologists had to encounter in their attempts to locate events and to regulate them by some fixed standard (illustrated by different modern weights and measures). The Greeks reckoned by Olympiads—cycles of four years beginning 776 B. C. The Romans' great epoch was the founding of their city, 752 B. C. They also used the lustrum, a cycle of four years; and events are very frequently recorded to have occurred in the consulship of such or such a one. The later Jews used the era of the Seleucidæ, 312 B. C., which era the Nestorians, it is said, still use. Prior to the adoption of our own era, the Christians used the era of Diocletian, 284 A. D.

To harmonize the conflicting and troublesome eras, one Scaliger,

an historian of the early ages of the Church, invented a new cycle to which chronologers might refer all dates. It consisted of the multiple of the years of the three cycles of the sun, moon, and indiction, $28 \times 19 \times 15 = 7,890$, and taking these cycles, as settled by the early Church councils, and tracing them backward, he found they would begin together in the year 710 before the creation of the world, according to our received account. This cycle would have been of great value and importance, had it not been superseded by the adoption of the Christian epoch, which, as already said, has made the use of all former epochs and eras unnecessary. The cycle just described is known by the name of the "Julian period."

Several of the ancient cycles were, however, used by the early Church in fixing what are called the "*movable feasts*"; these being regulated not by the solar year, as Christmas or the 4th of July is, but by the lunar year. But, as most of these feasts depend upon or are regulated by Easter, we need consider this one only. In the early days the churches of Asia kept their Easter upon the day on which the Jews celebrated their passover, i. e., on the fourteenth day of their first month, which began with the new moon next after the vernal equinox. The Western churches celebrated on the Sunday following the Jewish festival, both to celebrate the day and to distinguish between Jews and Christians. This difference having finally caused great dissensions in the Church, Constantine had a canon passed at the Council of Nice, that Easter should everywhere be observed upon the same day; and, to prevent disputes thereafter, four paschal canons were also passed, to the effect that "Easter shall always be observed on the first Sunday after the full moon which happens on or next after the 21st of March, which was then the time of the vernal equinox; and, if this full moon happen on Sunday, the Sunday following shall be Easter Sunday."

Then was called into requisition the lunar cycle, and tables were made showing the day of every month in every year, of the cycle on which a new moon would occur, and this table would have been correct for ever had the Julian year been correct and had the moon's cycle been nineteen years to the hour. The former, we have already seen, was not quite correct; and the new moon, although it occurs on the same *day* of the year every nineteenth year, does not occur at the same hour, but about one and a half hour earlier, which difference in a long course of years makes the tables all wrong and useless. In 1582, when the calendar was corrected, the computed equinoxes had been brought forward ten days, so that the full moon, on or after the 21st of March, was not always the first moon after the true vernal equinox—i. e., was not the moon which the Church canon prescribed. The reformation of the calendar, by dropping ten days, brought back the equinox to March 21st, as it was at the time of the Nicene Council.

Immediately after this council the Bishop of Alexandria, in Egypt,

was appointed to give notice to the Pope, and other dignitaries in various parts of the Christian world, of the time when Easter should be celebrated each year, until a perfectly correct cycle should be established. The most prominent cycle framed for this purpose was one by a mathematician named Victorinus. It consisted of the product of the lunar and solar cycle—i. e., $19 \times 28 = 532$. If this calculation had been without defect, any given day would have been the same day of the year, month, moon, and week, that it was five hundred and thirty-two years before or would be five hundred and thirty-two years after.

The Council of Orleans, A. D. 541, decreed that the feast of Easter should be celebrated every year, according to the table of Victorinus. But the tables derived from these data answer only for a limited time on account of the above-mentioned errors in the year and in the lunar cycle. Accordingly, the books which contain tables for finding Easter are good only until the year 1900, when new ones must be made for another period.

As the cycles were fixed by the Latin Church, the era of Christ began in the tenth year of the solar cycle and in the second year of the lunar cycle. Therefore, to find what year of the solar cycle any given year of our Lord is, we add 9 to the number of the year and divide by 28; the remainder, if any, will indicate the number of the year of the cycle. The year of the lunar cycle, i. e., the golden number, is found in a similar manner, by adding 1 to the given year and dividing by 19; the remainder will indicate the year of the lunar cycle.

After the Julian calendar had been used several centuries, the improved state of astronomy disclosed the fact that computed time did not keep pace with actual time, because the year did not consist of three hundred and sixty-five days and six hours but was about eleven minutes ten seconds less. Hence, by inserting an extra day for leap-year, we gain upon true time forty-four minutes, forty seconds, which makes an error of a day in about one hundred and thirty-one years; and hence, in 1582, when the correction of the calendar was undertaken by Pope Gregory, the error had amounted to ten days; i. e., instead of counting just 1,582 years it ought to have been 1,582 years and ten days. A correction was accordingly made by taking a leap of ten days and calling October 5th of that year October 15th. This change, as elsewhere stated, brought the vernal equinox to the 21st of March, where it was at the time of the Nicene Council. To prevent the recurrence of the same error in future, it was ordered that every fourth year should be a leap-year as before, but centurial years, though multiples of 4, should not be leap-years unless they were multiples of 400. The loss of $11\frac{1}{6}$ minutes yearly in time, as computed by the Julian method, amounts in 100 years to 18·6 hours. Calling this one hundredth year a common year gives a gain of one day, or 24 hours, which puts computed time ahead of actual time, $24 - 18·6 = 5·4$ hours, which, in 400 years, equals 21·6 hours, gain. Calling the four hundredth a leap-

year brings back computed time $24 - 21{\cdot}6 = 2{\cdot}4$ hours behind real time. To lose a whole day at this rate will require $10 \times 400 = 4{,}000$ years.

This arrangement seems simple enough to us now, but it required a convention of astronomers, summoned to Rome for this purpose, ten years to effect the adjustment. This is called the change from Old to New Style. It also changed the dominical letter, which occurred in this wise:

The dominical letter of 1582 was G, and, A being always the letter for the 1st of October, that day must have been Monday, and in regular order the 17th would have been Tuesday, whose letter was C. The change was made by calling the 5th day, which was Friday, the 15th, whence Saturday became the 16th and Sunday the 17th, whose letter we have just seen was C, whence C instead of G became the dominical letter for that year, N. S., and by this all subsequent Sunday letters were regulated. C is the fourth letter in backward order from G, hence the dominical letter of any year, N. S., was four letters backward from the letter belonging to that year O. S., and remained so until 1700, after which N. S. is but the third letter from O. S. because, according to N. S., 1700 is not a leap-year and has but one dominical letter. In O. S. it would be leap-year, and would have two letters. For the same reason, after 1800 N. S. it is only the second letter backward from O. S., after 1900 only the first backward, and so continues until 2100—the year 2000 making no difference, as it is a leap-year in both styles. After 2100, Sunday letter N. S. is the same as that of O. S., and gains one letter each succeeding century, except those which are multiples of four hundred, so that, in every nine hundred years after 2100, the N. S. and O. S. Sunday letter correspond. This furnishes a perpetual almanac.

This arrangement of the calendar, whose complete cycle is four hundred years, is called the Gregorian, from the name of Pope Gregory, through whose instrumentality it was made. It was adopted shortly afterward by all the Catholic countries of Europe; but Protestant countries refused to adopt it, notwithstanding its obvious superiority and correctness, because it was originated by Catholics. Enlightened public sentiment compelled its adoption in course of time, and an act was accordingly passed by the British Parliament in 1752, almost two centuries later, ordering that the 3d of September should be called the 14th, the error having by that time amounted to eleven days. The change was, however, not popular among the masses, because it changed the time of long-established festivals, and members of Parliament were insulted in the streets by the rabble calling after them: "What have you done with the days?" "Give us back the days you stole!"

We have already seen that tables were constructed showing on what days each new moon would fall in the whole lunar cycle, but,

though they would in nineteen years fall upon the same day of the month, they fell about an hour and a half earlier in the day, and this in sixteen cycles, or about three hundred and twelve years, would make a difference of one day. As these tables were published by ecclesiastical and secular authority, and could not be changed without such authority, another method was resorted to to find the times of the moon without the use of these tables. This method was called the *epact*, which we will now proceed to consider.

The lunar year, as we have already seen, differs from the solar year by about eleven days, i. e., if a new moon occur January 1st of any year, on January 1st of the next year the moon will be eleven days old, on the same day of the next year twenty-two days old, the next thirty-three days old, which equals a whole lunation *plus* three days. This cycle corresponds with the lunar cycle, and is constructed as follows:

Lunar Cycle.	Epact.	Paschal Limits.	Lunar Cycle.	Epact.	Paschal Limits.
1................	0	April 13	11................	20	March 24
2................	11	" 2	12................	1	April 12
3................	22	March 22	13................	12	April 1
4................	3	April 10	14................	23	March 21
5................	14	March 30	15................	4	April 9
6................	25	April 18	16................	15	March 29
7................	6	" 7	17................	26	April 17
8................	17	March 27	18................	7	" 6
9................	28	April 15	19................	18	March 26
10................	9	" 4			

From this table the astronomical moons not only for Easter but for the whole year can be found without variation of more than a day for about three hundred and twelve years, at the end of which time the new moon will fall one day earlier, when a new set of epacts must be made, the first of which will be 1 instead of 0, and the succeeding ones will be changed correspondingly. To find the age of the moon for any day of the year, we add to the epact the date of the month, and one for every month from March inclusive, the epact for a year being eleven days, or a day a month nearly. This sum, casting out thirty if required, will give the age of the moon at the given day: e. g., suppose it be required to find the moon's age on Christmas-day of the year 1868. We find, by the method already explained, that 1868 was the seventh year of the lunar cycle, whose epact in the table we found to be 6, to which adding 25 and 10 gives 41; from this deduct one lunation (29 days) = 12 days for the moon's age on that day. The epacts are calculated to show the moon's age on March 1st in any year of the cycle.

The rule for finding the Sunday letter of any year, as given in the "Book of Common Prayer," is constructed upon this principle: The dominical letter of the year of Christ, according to N. S., would have

been B A. Then for any year from 1800 to 1899 the number of letters used equals the number of years + $\frac{1}{4}$ the number of years (that number being leap-years) − 14 for centurial years which are not leap-years. This number divided by 7 gives the number of times all the letters have been used, and if the remainder is 0 the dominical letter is the same as that of the year 0, i. e., A (from March). Any remainders, 1, 2, 3, etc., will give corresponding letters, G, F, E, etc., as in the years 1, 2, 3, etc., A. C. Upon the same principle the dominical letter for the years of any other century can be found. But, as the number to be deducted for centurial years, not leap-years (equal 14), is an exact multiple of 7, the remainder will be the same whether it is deducted or not, and hence no account need be made of it, for it is by the *remainder* and not by the *quotient* that the Sunday letter is fixed. The above-mentioned rule will, therefore, not answer for any century but this one until the twenty-eighth century, when it can again be used, because the centurial number to be deducted will then be 21, which, being also a multiple of 7, may be disregarded.

In addition to these tables, another was constructed showing at a glance what letter corresponds to any day of the year; but, as this table is cumbersome and unwieldy, a device has been substituted which is very simple and answers all the purposes of a table. The letter for the first day of every month is always the same. These letters being known, together with the Sunday letter for any year, we can readily find what the first day of any month is, and consequently what day of the week any other day of the month is. The letters for the first of each are as follows, beginning with January: A, D, D, G, B, E, G, C, F, A, D, F, and, to assist the memory in retaining them, they have been woven into the following couplet:

1	2	3	4	5	6
At	Dover	Dwells	George	Brown	Esquire,
7	8	9	10	11	12.
Good	Carlos	Finch,	And	David	Friar.

SOME NOTES ON A DOCTOR'S LIABILITY.

By OLIVER E. LYMAN.

IT is related, as a legend of the medical fraternity, that the Emperor Augustus was once so highly pleased at a cure effected in himself by his doctor, Antonius Musa, that he raised that gentleman to the rank of knight, and relieved the whole profession from the burdens of taxation.

Probably at no time before or since that event has the lot of the physician been such a happy one. In the earlier days of Rome the

practice of medicine was despised and confined to the humbler ranks of society and to slaves. Not until the influence of Grecian civilization made itself felt in the Roman capital did physicians gain honor or standing.

In the middle ages the calling suffered a relapse, to speak medically. Surgery was in ill repute, and Sprengel tells us that in Germany no artisan would employ a young man as an apprentice without a certificate that he was born in marriage of honest parents, and came of a family in which were found neither barbers, bathers nor "skinners," as surgeons were called.

Even at the present day, although the meritorious claims of the medical and surgical practitioner have been recognized, and an honorable social status awarded him, his mind is not at rest. The advancement and refinement of ideas have begotten deeper anxieties, and a feeling of responsibility. So jealously does the law guard the lives and persons of the people, that every time the physician writes a prescription, or the surgeon makes an incision, he takes his purse, his liberty, or, perhaps, his life in his hand. The risk is not all on the part of the patient, despite a popular impression that the only pocketbook likely to be depleted or the only life liable to be sacrificed is that of the sick man.

In undertaking the care of a patient the physician enters into legal relations with him and becomes a party to a contract, which, although not expressly set forth in writing, is yet, in the eye of the law, fixed and certain, and one which subjects him, in case of a breach on his part, to legal liabilities. He engages that he possesses that reasonable degree of learning, skill, and experience which is ordinarily possessed by the professors of the same art or science, and which is ordinarily regarded by the community or by those conversant with that employment as necessary and sufficient to qualify him to engage in such business. He contracts also to employ reasonable and ordinary care and diligence in the exertion of his skill and application of his knowledge to the matter in which he is employed.*

It is not necessary, in order to sustain an action against him for malpractice, that there should be proof of gross culpability on his part. He is on the same footing, and subject to the same degree of liability, as any other person who is engaged in the performance of services requiring skill and care. Both are equally responsible for a failure to exercise proper care, and for negligence in the discharge of the duty imposed upon them.† But extraordinary care is no more contracted for than the possession of extraordinary skill. If the physician has employed ordinary skill and care in the management of his case, he is not responsible if success does not crown his efforts. But, on the other hand, if he does not bring to the treatment of a disease the ordinary amount of skill possessed by those in the same

* T. Foster, New Hampshire, 460.

† 75 New York, 15.

profession, it is immaterial how high his standing may be.* He is liable for the want of it. If, moreover, possessing skill, he undertakes to heal a wound or cure a disease, and through his neglect the party is not cured, or is impaired in health by the treatment, he is also responsible. Behold the two horns of the dilemma which threaten the physician! If he has skill, and neglects to employ it, he is liable in damages; if he has not skill, he is equally liable. The injured party may bring his action to recover for damages resulting from both, and recover, on proving damages resulting from either.

Once having incurred the liability, it sticks like a leech. Retiring from the case is of no avail to shield him against the results of his prior negligence or malpractice. Nor will neglect to send in a bill. Such failure might reasonably be interpreted as an admission of neglect, and as an evidence of consciousness on the part of the physician that he was not entitled to pay, and that his services were worthless.† It has been held also that it is no defense that the services were rendered gratuitously.

This liability is, for the most part, a civil one, and redress can be measured by a monetary standard. If, however, the patient die, and his death is presumptively owing to the treatment received and caused by it, criminal proceedings may be instituted against the doctor, and in such cases the charge of criminal malpractice is not infrequently preferred. Now, the practitioner may never actually have had that malicious or criminal intent which is an essential element of a crime; but, if he has been guilty, for instance, of gross rashness, gross ignorance, gross negligence, or the most criminal inattention,‡ the law very properly infers such criminal intent, and the physician finds himself held for manslaughter. In England the law is, "If one, whether a medical man or not, profess to deal with the life or health of another, he is bound to use competent skill and sufficient attention; and, if he cause the death of the other through a gross want of either of these, he will be guilty of manslaughter." There is nothing unsound in that doctrine.

The physician does not, however, contract for freedom under all circumstances from errors of judgment. The man who possesses ordinary skill is presumed to have ordinary good judgment, and, if it be fairly and conscientiously exercised, and the case is one of reasonable doubt and uncertainty, any errors and mistakes are upon employers alone.

Such is the law in New York. In Maine, however, not so very long ago, a verdict of heavy damages against a physician for alleged malpractice in a case of amputation was sustained on appeal. The Court, nevertheless, expressly admitted that the verdict was found against the defendant on the ground of his error of judgment in not

* 60 Barb. New York, 508. This is a leading case on the subject of malpractice, and the writer has made frequent annotations therefrom.

† 47 New York, 186.

‡ Bishop.

removing more than he did of the amputated limb. Such a verdict is tantamount to saying that the physician ought to have known better what course to pursue, and was therefore guilty of ignorance, on which ground it would, perhaps, have been better to base the verdict than on an error of judgment.

Fortunately for the profession, there are some limitations upon its liability. Ordinarily the physician is supposed to possess a familiarity with the characteristics of the dominant disease. As it has been summed up: "His diligence and care will be exercised in watching for and guarding against the numerous accidental influences which, if overlooked, may delay or even prevent the restoration of the patient, such as latent predisposition to certain diseases; a lack of vital or recuperative power in the patient; the effects of melancholy and of other passions of the mind; the effect of the want of pure air and good food; of careful attendance and nursing; the neglect of the patient to follow the physician's advice, or to take the medicines which he prescribes."

A surgeon once, in a case of dislocation of the elbow-joint, replaced the bones and put the arm on a pillow; with the part below the joint at a right angle with that above it, and directed the application of cold water, but omitted to give warning that the arm must remain in that position. Assuming for the moment that such treatment was enough, the Court declared such omission to be culpable negligence on his part. Had he, however, performed his task skillfully, omitting nothing, and then the patient had neglected to comply with his directions, the surgeon's liability would have been limited. For in the case of the sane it is the patient's duty to coöperate with the physician or surgeon, and conform to necessary prescriptions. If he will not, or under pain can not, his negligence is his wrong or misfortune, for which his physician is not responsible.*

If the patient's neglect to obey the reasonable instructions of his medical attendant, contributes to the injury complained of in an action for malpractice, he can not recover.† Contributory negligence is a good defense, and in this respect the patient is "on all-fours" with the man who is run over while walking on a railroad-track without authority. Neither can recover. While there may have been negligence on the part of the engineer or the doctor, yet, the pedestrian and the patient being equally at fault, no recovery can be had. But, if the patient has neglected to use necessary precautions, because lulled into a sense of security by the doctor, the doctor will be liable. A refusal, however, on the part of the patient, to prevent an attempt to remedy the injury already caused by malpractice, does not necessarily preclude a recovery, if the refusal was made without reasonable assurance that the attempt would be successful.‡ And it would seem that refusal,

* 22 Pennsylvania Statutes, 261, 7 Phil., 138.

† 25 Ohio Statutes, 86.

‡ 68 Pennsylvania Statutes, 168.

even after assurances of success, would be just and proper. What weight have assurances from a negligent physician? Is there any reason to suppose that, after having broken his implied contract for care and skill, he is in any better condition to observe his express one? But, if the physician guarantees a successful issue out of the trouble, he will be held responsible in case of failure to effect a cure, although, ordinarily, he would not be liable if he had employed such care and skill as were above spoken of.

The discussion of this question of responsibility opens up the ancillary and possibly more interesting one, how far can the physician or surgeon deviate from the established rules of practice without being charged with negligence in case of an injury to the patient arising from such deviation?

An English judge says, "Any deviation renders him liable."* This is rather severe, and, if practically applied, would effectually bar progress in the practice of physic and surgery. Every practitioner would be as antiquated as a Galen or Hippocrates, and the sick and diseased would lose all the benefits and improvements which the experience of years and the researches of science furnish. The rule works a hardship. In striving for protection, it causes deprivation. American authorities introduce a modification. If it is shown that physicians or surgeons have applied a different system of treatment and found it to succeed as well as or better than the one prescribed, it is not negligence, so says a New York judge, to resort to the system thus practically tested. In other words, one can not become an experimentalist, except at his peril. If a writer on treatment, or, in the absence of such authority, practical surgeons prescribe certain grooves, in those grooves he must run. But, if others have previously taken the risk and been successful in a new line of treatment, it may be followed with impunity, and will shield the practitioner from the charge of malpractice, provided that the cases in which it was tested were substantially the same as those treated of by the writer or by the practical surgeons, and provided the treatment thus resorted to has been successful to such an extent as to leave no doubt as to the propriety and safety of adopting it. If the case is a new one, the patient must trust to the skill and experience of the physician he calls in. So also must he, when the injury or disease is attended with injury to other parts, or other diseases have developed themselves, for which there is no established mode of treatment. There can not but be some cases when latitude must be allowed the physician in the application of remedies. But, when the diagnosis reveals a disease for which there is a well-established method of treatment, the practitioner departs from it at his risk.

This rule is for the best welfare of the community. It protects against reckless experimenting, while it permits the adoption of such

* 2 Espinasse, N. P., 601.

changes as have been thoroughly tested and their benefits demonstrated. It is also quite in harmony with the spirit of the profession, which may, perhaps, in the phraseology of the day, be said to be "conservative—not too conservative, but just conservative enough."

Men who profess to deal with human life and health adopt radical changes with cautiousness. Yet the members of no other profession, probably, are more ready for discussion. Theories are constantly advanced and—upset. Others are maintained and imperceptibly shaded off into practice. Galen was an authority for thirteen centuries, when a revolution of medical ideas took place, and his works were burned by Paracelsus and his followers. The homœopathic offshoot of what is known as the regular school of medicine obtained a foothold only after years of debate and discussion. It is only a few years ago, in 1855, that a judicial decision was necessary to establish the right of a homœopath to the title of doctor,* and it is not so very long ago that an allopath thought he could call a homœopath a quack with impunity. In a slander suit in which he was a party defendant, the Court, however, convinced him of his mistake.†

This incident illustrates the disposition of the older school toward innovations and the vindication by *one* new branch of practitioners of its claim to recognition. But, surprising as it may seem, such were the statutes in force in New York State from 1844 to 1874, that all other classes of practitioners were equally countenanced by the law. Allopath, homœopath, hydropath, or whatever devious path he followed, the man who made the practice of physic or surgery a business was entitled to the name of doctor, and to the protection afforded by the courts.‡

A *résumé* of the statutes which have been passed in the Empire State regulating the practice of physic and surgery reveals a most curious struggle against quackery, in which it will be seen that quackery was for the most part triumphant. About the beginning of this century our law-makers undertook a reform in the matter of practice of physic and surgery, and made it a penal offense to do either without being duly licensed for the purpose. There being no enactment in special terms against the recovery of compensation for such unlawful services, the Legislature, in 1806, passed another statute expressly declaring that any person who should commence practice without a license, after the first day of September next ensuing, should "for ever thereafter be disqualified from collecting any debt or debts incurred by such practice." This was a severe blow to "quacks." It was penal for them to practice, and they had no friend in the Court. Truly, the way of the transgressor seemed hard. The bonds were carefully examined and readjusted in 1813. The revision of 1830 contained similar provisions. The unauthorized practice of physic and surgery was declared "a misdemeanor punishable by fine or imprisonment, or both."

* 4 E. D. Smith, New York, 1. † 42 New York, 161. ‡ 4 Denio, New York, 60.

This provision was short-lived. The work of the lobbyists of the irregular party began to tell. In April of the same year an act was passed which made the offense penal instead of criminal, and which also declared that such penal provisions should "not be deemed and taken to extend to or debar any person from using or applying for the benefit of any sick person any roots, barks, or herbs, the growth or produce of the United States." Mark the charming protective air in that statute! Under a free construction it reads, "However dangerous they may be, if you only use *American* roots and products, we don't care what you do." Quackery was again the upper dog. But the struggle was not over. Although on top, the other dog had a vicious grip upon him. The empiric was still unable to recover compensation from delinquent patients. He was equal to the emergency, and took his pay in advance. It took the licensed practitioners four years to make the next move, which was a feeble one. In 1834 the exemption from the penalty was confined to such as used the herbs, etc., without fee or reward. The next year the enactment was blotted out, and the two parties stood as in 1830. For fourteen years the condition of affairs remained unchanged, when, in 1844, all criminal and penal laws against the unlicensed practice of physic and surgery were repealed, as well as every enactment which prohibited any person from recovering compensation for services as physician or surgeon, whether licensed or not. One doctor was as good as another in the eye of the law. Quackery had achieved a complete victory, and was liable only in cases of malpractice, or gross ignorance, or immoral conduct in such practice. The standard of admission to the profession was lower even than it was in the time of the Christian emperors. At that early day physicians were required to undergo an examination to prove their competency to perform professional duties before they were permitted to practice. If any practiced without a license they were heavily fined.

For thirty years the situation remained unchanged. From 1844 to 1874 no step was taken to purify the system. But, in the latter year, our legislators awoke. Among other regulations it was declared "a misdemeanor for any person to practice medicine or surgery in the State unless authorized so to do by a license or diploma from some chartered school, State board of medical examiners, or medical society," or who should practice it "under cover of a medical diploma illegally obtained." The punishment was to be a fine of not less than fifty dollars nor more than two hundred dollars for the first offense, and for a subsequent offense a fine of not less than one hundred dollars nor more than five hundred dollars, or imprisonment of not less than thirty days or both. This was an excellent move, and, supplemented by the one in 1880, has been fairly effectual in driving out unlicensed practitioners. The enactment of 1880 provided that no person shall "practice physic or surgery within the State unless he is twenty-one years of age, and either has been heretofore authorized so to do pursu-

ant to the laws in force at the time of his authorization, or is hereafter authorized so to do," either by a license from the regents of the University of the State of New York, a diploma of an incorporated medical college within the State, or a diploma of a similar institution without the State, provided it be endorsed as approved by some proper medical faculty of the State. But every physician and surgeon, with the exception of practitioners of ten years' standing and a few others, must register in the office of the clerk of the county where he is practicing, or, if hereafter authorized, intends to practice, his name, residence, and place of birth, together with his authority to practice, to all of which he must subscribe. He must also make affidavit as to the manner of his license or authority, the date of the same and by whom granted, which, if willfully false, shall subject the affiant to conviction and punishment for perjury. Any one who violates either of these provisions or the one in regard to practicing, or who shall practice under cover of a diploma illegally obtained, shall be deemed to be guilty of a misdemeanor, and on conviction shall be punished in a similar manner to that provided in 1874.

Such is the law at present in New York State. Much has been accomplished, but something yet remains to be done. There are weak points in the laws, noticeably the exemption from the operations of the act of 1880 of ten-year practitioners. While this may have been inserted to save reputable men from unnecessary trouble, does it not also leave a foothold for a disreputable class of an equally long standing? It is true, the law of 1874 is in force, declaring unlicensed practice to be a misdemeanor; but its inefficiency in meeting the evil necessitated the move of 1880.

The profession, however, is in a fair way to be purged of most that is foul in it. Perfection is not a mortal attainment. Let the community, then, be thankful for its present measure of protection. Against "quacks" our Legislatures are working. For malpractice the courts furnish redress.

ORIGIN AND STRUCTURE OF VOLCANIC CONES.

By H. J. JOHNSTON-LAVIS, F. G. S.

I.

OUR general ideas of its appearance, if we have never seen a volcano, differ considerably from what we find when actually brought in contact with one.

We always have the tendency to associate a mountain as the site of volcanic outbursts. Such is the case in general rule, though with many exceptions. In fact, the variations are so great that in many cases we should be inclined to attribute the extreme forms to totally

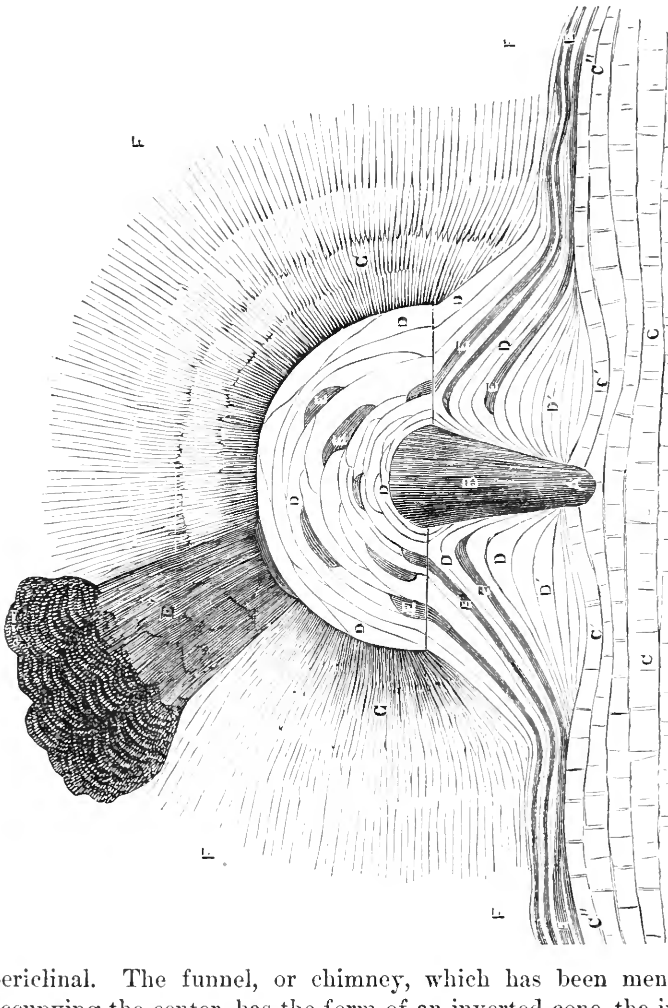
different origins, were there not existing intermediate ones which demonstrate that they are all varied modifications of one almost uniform series of physical effects.

Thus to one looking first at the vast volcanic cone of Cotopaxi, almost perfect in form, and comparing it with the ring-like cavity of Astroni in the Phlegrean field, it would be almost incomprehensible to believe that these two extremes are the result of identical forces acting much in the same manner and producing such widely different effects. But in the latter district we have not to travel far to find other vents that act as interpreters in explaining these variations of forms. In the present paper it will be my endeavor to explain the building up of what we will call a normal volcanic cone, and then afterward to point out the extreme variations to which such a mass is liable.

Given a large volume of heated vapors and liquid rock that has burst its way upward through the subjacent strata, in what way will it manifest its presence, and what traces will it leave behind? This vapor does not seem to exist separately from the molten rock or lava at any great depth, but as it approaches the surface the enormous pressure is reduced, the water and other gaseous matter expand, separate themselves into little bubbles scattered through the highly heated liquid magma. These will collect, to a certain extent, and from their lightness will float to the surface of the lava and there burst. The vapor may have commenced to form at great depths, and in its upward journey have become exceedingly bulky, so when it reaches the surface it would escape with a loud explosion. If we watch lava in the crater of a volcano in a quiescent state, such as Vesuvius, we see these great bubbles, so to speak, continually forming and bursting. As they burst, the surface of the vesicle is blown up as soft, pasty fragments, to the height of many feet. These masses appear black by day, but red-hot by night; they may cool or not, before falling; if the latter, when they strike the ground, they adapt themselves to the irregularities of the surface, and form, as it were, a cast thereof. This condition is much exaggerated at the first outbreak of an eruption; the vast column of fragments often reaches an altitude of two and three thousand feet. There the pieces ascending meet those descending, and so there is a continual grinding going on between them; the fine dust is taken by the wind and transported often many miles, forming the so-called clouds of volcanic ash. The larger fragments (or *lapilli*, as they are named) may again fall back into the opening or around its edge, thus building up an annular bank. This is really the foundation of the cone.

If we speculate for a moment on the formation of such a heap, we shall see that the first strata deposited will be horizontal, but somewhat thicker toward the axis of explosions. (See D, diagram.) This, however, as the action continues, will begin to arrange itself in a

direction slanting away from the axis, until the beds reach the maximum angle of repose of the rock-fragments in question as the beds (D D) on diagram. Thus we have constructed a conical mass in the center of which is the volcanic chimney (B), and, dipping away on all sides at angles, varying generally between 20° and 45°, we find the strata composing the cone (D, E). This arrangement is often called



DIAGRAMMATIC BIRD'S-EYE VIEW OF A VOLCANIC CONE.—The upper part is supposed to be removed by an horizontal section, and one half of the remaining base by another longitudinal one. A, vent; B, chimney; C, basement rock, compressed downward at C′ and upward at C″; D, ash-beds; E, lava streams, one of which, E′, is seen to have run down the slopes, G, of the cone, and spread over the plain F.

periclinal. The funnel, or chimney, which has been mentioned as occupying the center, has the form of an inverted cone, the inclination of its sides and its diameter necessarily being proportional to the volume and force of the escape of vapor, and also to the nature, form, and size of the surrounding fragments, forming the growing cone, which have already been ejected. The upper, or basin part, is technically called the crater. The vapor only may have made its appear-

ance at the surface, and in fact may have parted company with the lava at very considerable depths.

Or the latter may have been forced up almost simultaneously with the vapor, and poured out over the edge of the primitive cone. This, however, is not the general rule, for an escape of much gaseous material nearly always precedes for a variable period the appearance of the lava. In fact, when a volcanic outburst has forced a convenient passage for the vapor, the exit of liquid rock seems of secondary importance, for generally the terrific explosions, earthquakes, and subterranean thunder that accompany the first stage of eruption are more or less absent, or at least much diminished during the welling up of the fluid rock. If, as in the latter case, a cone of some considerable size has been formed, the lava will rise and occupy the whole of the crater-cavity. Two things may happen: If the cone which now forms, as it were, an embankment around the lava is of sufficient strength to withstand the pressure of the fluid mass contained within it and the continual explosive vibrations, the liquid rock pours out over the edge of the crater down the side of the cone, and may continue its course for variable distances from its starting-point ; or if, on the other hand, the cone is too weak to support the strain, it may break away and give free passage to the lava through the breach. This condition is well illustrated in many of the Puys of central France. There is another series of events, that is to say, the formation of dikes, about which we shall have more to say anon.

The lava may form a series of little streams over the cone sides, changing their situation according to the point at which the crater is lowest. Here it will cool, forming a buttress of rock on the slopes of the cone. These masses will be covered again by *lapilli*, other buttresses formed in the same manner, and thus the cone built up higher and made stronger. If we see it in section, as in the diagram, it will present a stratification of alternate beds of rock and cinders. This, however, is misleading. The lava-streams do not form a continuous sheet surrounding the cone—see diagram, where they are seen cut through in transverse section. When a mountain of some height has been formed, it then becomes liable to fracturing, and the formation of so-called volcanic dikes. Mr. Mallet, in a communication to the Geological Society,* thoroughly explained this condition of things. As we have seen, the cone may form an embankment around the column of lava occupying the chimney and crater, consequently there is an enormous pressure put upon the supporting wall of loose material. Let us begin by taking the pressure of a column of water thirty-two feet high, then let us say another four thousand feet, roughly the altitude of Vesuvius, and compare that with a column of molten lava, whose specific gravity is two or three times that of water. This would be an interesting calculation: given the specific gravity of

* "Proc. Geol. Soc.," London, vol. xxxii, part iv, p. 478.

Etnean lava, the height of the crater, what is the unit of pressure at the sea-level?

The outward pressure of the lava will increase in proportion to the depth. Also the cone wall necessarily increases in thickness from above downward. This, therefore, tends to counteract the augmentation of pressure from within. Nevertheless, when this is so great inside that the inner layer of the chimney must necessarily be compressed outward, and therefore the circumference made larger, the consequence is that at one point it begins to yield, forming the commencement of a perpendicular fissure, radiating from the central axis, and, by the same course of circumstances, this will gradually spread outward. Mr. Mallet,* in his paper describing these mechanical effects, aptly compares them to the bursting of a gun where the greatest strain is on the inner lining, and consequently the fissure commences in this and radiates outward. In a volcano, as the fissure is formed, it is immediately occupied by the fluid lava. If the fracture extends far enough it may reach the surface, where it may form one or more parasitic cones. By the explosion of vapor from the lava, these cones are generally formed in a row, radiating from the mountain axis, and in a step-like arrangement. This is attributed to the fact that, as the lava and vapor escape, the former reaches a lower level, and here forms the second, third, fourth, and so on in succession. This was well illustrated in 1861 at Vesuvius, where seven such hollow mounds were formed, the first being the largest, and gradually diminishing downward, as the igneous forces became exhausted. The pressure of the contained fluids may be so great that the entire side of the mountain may be rent asunder with the rapid escape of the contained lava, thus forming a breached cone. In the above-mentioned paper,† in fact, it is supposed by the author that all such have originated in this manner. A third condition of things may be brought about: this fissure may only extend a certain distance from the chimney, never showing itself superficially, and the lava occupying the fissure will gradually become cooled and consolidated, forming a perpendicular sheet of rock or dike, as it is called, radiating from the mountain axis. These are well illustrated in the Val de Bove of Etna and the escarpment of Monte Somma. In the former,‡ Sir Charles Lyell adopted the plan of endeavoring to find the orientation or point of convergence of these dikes, to localize the site of the old crater supposed to have produced this curious cavity. This was followed by the untiring work of Mr. Mallet in the latter locality, to determine where the axis of Somma should be placed. In the latter case twenty-seven of the largest were chosen, but, when their directions were taken by a careful survey, they were found not to converge at one point, but in some there were discrepancies of upward of two

* "Proc. Geol. Soc.," London, vol. xxxii, p. 478. † Ibid., vol. xxxiii. p. 740.

‡ Sir C. Lyell, "Lavas of Mount Etna," "Phil. Trans.," 1858.

kilometres between the points of melting. This we can well understand when we know how irregularly the cone is constructed, and how buried *coulées* of lava may derange the direction of the fracture, such as we exaggerately see illustrated in some old denuded trap dikes, threading their way along planes of least resistance. There is another source of error—that is, that so little of the projecting edge of the dike is exposed to accurately take its strike, thus rendering us unable to determine by this means the locality of an old volcanic axis.

If we look at the figure, at the surface C′ C″ of the subjacent rock, we observe it forms a wave-like line in section. It is again to Mr. Mallet * that credit is due for the explanation of this somewhat anomalous appearance. It is known that the ground under high towers and other heavy structures is gradually compressed by the immense superincumbent weight. At the same time a corresponding elevation takes place around the base of the structure. This is just what occurs in a volcanic mountain. The immense pressure of superposed material compresses, to a variable degree, the subjacent rock, according to its yielding power. This will be greatest where the column of materials is highest, that is to say, exactly under the crater edge as at C′, in the diagram. This causes a corresponding rim-like elevation around the base, or at the toe of the cone as at C″, in the diagram.

The materials which go to form the cone are the subjects of our next consideration.

Taking as our standpoint the old but useful division of lavas into basaltic or basic, and trachytic or acidic, let us look at the characters presented by these two great classes of rocks. Basalt and its congeners are generally heavy, compact, dark-colored, more or less crystalline. Very rarely vitreous in structure, and only in small patches. Excessively fluid in the molten state, losing heat and fluidity slowly, and then passing rapidly from the liquid to the solid state, the liquid fragments of which, when ejected from the crater, generally fall still plastic, and, when cold, form an excessively ragged, hard, angular mass. The surface or scoria of the lava-stream also is hard, and not easily broken, the main mass itself being very apt to form the well-known columnar structure. On the other hand, the trachytic or acidic lavas, when molten, are very viscid, which condition increases rapidly as it loses its heat, so that it flows very short distances, often stopping midway down the steep side of the cone, as in the island of Vulcano, or forming a large, boss-shaped mass around the vent.† When cooled slowly it crystallizes, but it is much more liable to form a vitreous mass or obsidian than the basaltic rocks, resulting probably from its high percentage of silica. In fact, it behaves very much like glass or slag in its physical transformations. As on the surface of the glass pot is

* R. Mallet, F. R. S.: "Hitherto Unnoticed Circumstances affecting the Piling up of Volcanic Cones" ("Proc. Geol. Soc.," London, p. 740).

† P. Scrope, F. R. S., "Volcanoes," 1862.

formed a frothy-like mass which cools as a light, spongy, vesicular material, so by the explosions from a trachytic volcano, similar masses are formed and thrown out, well known as the useful pumice-stone. This variety of lava produces often a very ragged surface, much less durable to mechanical agents than that of the other class. Again, it is very light, often more so than water. These differences, of course, merge into one another, lavas often occurring that are not easy to classify; but for our purposes the extremes are more suitable of illustration. Also, the same volcano may at different periods have yielded successively each of the varieties of igneous matter. Vesuvius, for instance, has ejected materials of each of the classes, and many distinct varieties of the basic. Obviously the discordance of these physical characters must necessarily produce considerable distinction in the physical conformation of a volcanic region in general, and of the cone in particular. It may be our want of a thorough examination, but it is apparently the rule that dikes are much less common among the trachytic volcanoes than the basaltic, whereas, apparently the largest number of breached cones belong to the former, thus contradicting to some small extent Mr. Mallet's * dike theory already referred to. Thus we see that all the solids so far derived from a volcano, lava, scoria, lapilli, ash, etc., are all mechanical modifications of the one molten rock. There is, however, another important factor of which we have not spoken, the so-called ejected blocks. These are nothing more than fragments of the solid rock walls of the volcanic chimney or vent. They, therefore, vary according to the rock through which the igneous outburst has occurred. Thus we find among the constituents of the Vesuvian slopes a great variety of such blocks, among which the beautiful minerals yielded by Somma are found. These may be roughly divided into three classes:

1. Limestone variously metamorphosed, derived from that like Castellamare, which dips under and forms the Vesuvian platform. These fragments are sometimes so altered, by the intense heat, pressure, and chemical action to which they have been subjected, that it is only by studying the intermediate varieties that their origin can be detected. It is these blocks that are richest in the Vesuvian minerals.

2. Calcareous mudstones containing late pleistocene fossils, these being in a very perfect condition, containing generally a great number of well-preserved leaves. This rock is curious, as being of apparently (though not real) volcanic origin, and containing marine fossils without submergence.

3. Trachytic and corresponding tufa, also basaltic tufa. These are also masses of highly micaceous feldspathic rocks, that probably are nothing more than the excessive metamorphosed condition of the first class.—*Science Gossip.*

* "Proc. Geol. Soc.," London, vol. xxxii, p. 478.

MAN AND THE VERTEBRATE SERIES.

By CHARLES MORRIS.

MAN stands as a connecting link between two worlds—the world of matter and that of mind. He forms the apex of the development of matter, the loftiest effort of evolution in substance. Mind, it is true, has its foundation in the regions of life below him, but all its superstructure—the towering arches and lofty pinnacles of the ideal—rests upon the human intellect. Man thus forms the gateway which Nature has placed between her two vast kingdoms of substance and thought, and in the human brain these two realms meet and merge, energy flowering into intellect, substance into soul.

But is the human form the true culmination of the development of matter? Has Nature really reached in man her acme in this direction? A deductive philosopher would perhaps answer this question in the affirmative, on the theory that Nature would not stop short of the most completely developed physical form, as the starting-point of mental evolution. He might claim that a perfect soul could only arise in a perfect body, and that, as Nature is striving toward perfection, she must lay all her foundations at the highest possible point.

But inductive science starts with no theories. It builds its theories out of facts, not its facts out of theories, and follows Nature upward from her roots, not downward from her branches. What, then, do the facts of Nature say as to the question of animal evolution? Is man truly the paragon of animals?

Unfortunately, this question opens before us a field of investigation too broad for consideration in a single article. We have already seen that Nature has exposed organic forms to an almost unlimited variety of conditions, during the long geologic ages, and has probably tried every line of development of which organic life is susceptible. By a close review of the various animal types, their advantages and deficiencies have been traced, and we think it has been shown that the vertebrate type is the one suited to the highest evolution, and the one toward which all the lower forms tend in their highest representatives.*

For a complete review of organic form development the plant types should also be considered, but we must confine ourselves in this article to a consideration of the vertebrate type of animals alone.

And first, What are the causes, what the modes, what the laws, of evolution? What features in one animal constitute superiority to another animal? These questions we shall but briefly answer. There are certain requirements absolutely necessary to the continuance of

* "Evolution of Organic Form." "Popular Science Monthly," November, 1880.

animal life. One of these is a sufficient supply of food ; a second, a sufficiency of oxygen ; a third, proper nutritive and excretory organs ; a fourth, proper reproductive powers.

The first and fourth are of most importance in this connection, for they are in constant conflict with each other. The quantity of available food is far more limited than are the possibilities of animal increase. Necessarily, then, the latter is restricted by the former. A crowding-out process ensues, and only those best adapted to obtain food survive.

But an equally necessary result is an adaptation to new sources of food, one of whose earliest consequences is the production of carnivorous animals. Thus the crowding-out process becomes, in part, an eating-out process. The animals thus exposed to destruction would necessarily be at a marked disadvantage in the race for life, were not some protection provided them. For safety they need weapons of defense or means of escape. It all comes to this, then, that the strongest, swiftest, best-armed, and most alert animals will survive, these qualities enabling herbivora to escape their foes, carnivora to overcome their prey.

But there are two ways in which this survival may be attained: one by adaptation to a few simple conditions ; the other by adaptation to many and complex conditions. The wider the scope of adaptation in an animal, the greater is its functional complexity, and the higher its organic position, as compared with the more simplified tribes.

Still another requisite of the utmost importance is the principle of division of labor. No organ can do two distinct things equally well. If forced to perform two or more labors, there must be a degree of imperfection in its work, or its ability in each direction must be greatly limited. Therefore evolution is in the direction of separation of labor, each organ tending to become confined to one kind of work, to which alone it becomes adapted, but in which it produces better and wider results.

Seeking, then, for the features likely to distinguish the most highly developed animal, we may safely say that they will appear in that animal exposed to the most complex conditions, adapted to the greatest variety of food, possessed of the most fully specialized organs, capable of using its innate forces to the best advantage, and commencing its individual existence with the best start in life.

With this preliminary we may proceed to a closer investigation. Vertebrate animals occupy every kingdom of nature—the sea, the land, and the air—but not under equally advantageous conditions. The inhabitants of the sea, for instance, are exposed to decided disadvantages, and lack certain important incentives to development. Their vital activity is necessarily much below that of land-animals, from the limited quantity of oxygen obtainable by water-breathers as compared with air-breathers. Their sensory acuteness, also, is less developed. Light comes to them dimmed, sound comes to them dulled, the

water which surrounds their food must blunt the senses of taste and smell, and there is little besides water contact to develop touch.

Also the conditions surrounding attack and escape are here greatly simplified. The water presents no lurking-places, no ambush, except to the inactive dwellers upon the sea-bottom. And, by relieving its inhabitants from the effects of gravitation, it renders rapid motion easy, with slight muscular exertion. Thus the easiest, most natural, and most effective means of assault and defense is by swift powers of swimming.

The same principle holds good in the case of the dwellers of the air. There is here no lying in wait for prey nor hiding from assault. Flight is the most effective and most ready means of attack and escape, and the only one available in the fields of open air. Thus purely water and purely air animals fail to develop a variety of resources in this particular.

Moreover, as fish are at a disadvantage from their imperfect oxidation, so are birds at a disadvantage from the effects of gravitation. The weight of fishes is almost or entirely supported ; that of land-animals partly supported ; that of birds almost unsupported. Gravitation in them, then, must be mainly overcome by muscular exertion. Thus a large proportion of their life-force is exhausted by the effort to sustain themselves against the constant downward pull of gravity. This places them at a disadvantage with animals capable of using their forces for more varied purposes.

Indeed, we find, both in fishes and in birds, a tendency to avail themselves to some extent of the advantages which the land-surface gives. And those that most display this tendency comprise the species of most varied resources, and with the greatest degree of functional adaptation. Many species of birds, in fact, have found safety so much more assured on the land, that they have lost, first their instinct, and then, in some cases, their power of flight, and have become, virtually, surface-animals.

We may descend to the invertebrate world for one marked instance of this. The ants are acknowledged to be the highest of all insects in functional development. Their eyes, for instance, are more simplified than those of other insects ; and, if we class mental attributes as nerve-functions, their claim is indisputable. Yet they have forsaken the air and taken to the earth in preference, the females casting off their wings as if in scorn, after a temporary use of them.

Of all the fields of life for the varied display and functional separation of the animal forces, we are thus brought to the land-surface as obviously the best. Here an abundant supply of oxygen assures vital activity ; the firm ground largely supports the weight, and releases the muscular powers for employment in other directions ; the abundance and variety of vegetable food sustains vast numbers of animals ; the great diversity of conditions causes wide specific variation ; while

the simplification of modes of assault and defense in water and air is replaced here by the most varied motions, such as creeping, running, leaping, climbing, etc., by a diversity of ambushes and hiding-places, and by the necessary adaptation of carnivora to numerous modes of attack, and of herbivora to as numerous modes of escape.

In fact, the specific variations in birds spring from their relations to the surface. Here, as a rule, they seek their food. Here their mental powers arise. Here they develop other functions than flight, other organs than wing-muscles. And it may be that the variations in the fish type spring principally, in like manner, from their relations to the sea-bottom, and the adaptations of carnivorous fish to the powers of escape of forms thus varied.

Thus in the process of animal evolution we reach the dwellers upon the land as the most developed, and the best situated for further development. Those land-animals that retreat to the other fields of life retrograde in consequence. The whales have gone back in their functional development until, in many points, they are affiliated with the fish. The bats have sunk toward the bird-level. So the lowest in function of land-animals are those which retain close affinities with the air and water life of their ancestors, or have but lately migrated to the land. The wingless birds are low in mind and in animal function. The amphibia rest at the lowest level of land-animals. The reptiles are but a step above them.

In the latter class, it is true, there are many which have long broken loose from all connection with a water habitation. Most notable among these are the serpents. But the latter, from their habit of seeking safety in concealment alone, have retrograded functionally, their limbs disappearing, and their bodies being extended prone upon the earth. This location, while an undoubted advantage as affording concealment, is a disadvantage in development. The prone condition of the serpent has caused its limbs to disappear, as useless. Its ribs have taken the place of limbs, and the body has extended in length sufficiently to increase the number of these imperfect limbs, and thus render them more available for motion. Its sensory organs have necessarily become less acute from the disadvantages of position. Gravitation is largely overcome, by the full support of the body upon the earth. But it is replaced by a friction which is equally disadvantageous.

Thus, if we would seek the type of land-animal most likely to develop functionally and mentally, we must look in an opposite direction to that taken by the serpent. The protection that is gained by concealment is a retrograde form. The animals that advance most rapidly are those that are least protected, either by powers of concealment, of flight, or of muscular vigor.

For what does development mean, in its true sense, but extended experience of nature? The greater and more varied the experiences

attained by any animal, the best suited it is to cope with nature. And if this variety of experiences extend through the life of a species, it becomes adapted to escape from more varied descriptions of peril and to obtain food in greater variety and quantity.

Thus, in seeking the form of animal most fairly planted in the path of true development, we must look for one capable of attaining to wide experience of nature, and adapted to evade perilous or to take advantage of beneficial conditions of the most diverse character.

These considerations lead us to a conception of the description of animal most likely to appear as a development from the low amphibian and reptilian forms. It must have sensory organs acutely adapted to all of Nature's most active forces, as light, heat, sound, and contact in its several kinds. It must be elevated above the surface sufficiently to give it the widest range of vision and hearing, these most important of the perceptive powers being specially active at the highest elevation of the body. It must rest upon the earth in such a way as to reduce friction to a minimum, so far as is consistent with proper support; and its powers of flight, of concealment, and of physical strength, must be sufficiently reduced to force it to seek other sources of safety, to adapt its organs to more varied functions, and to develop new features of mental activity.

What will be the form and the conditions of exposure to and defense from danger, of this most highly developed animal, adapted to gain the widest experiences, and to the greatest organic division of labor? It must, of necessity, display in its evolution every intermediate gradation of form upward, from that of the lowest vertebrate. Its form must be founded upon that natural to the fish.

Now, the fish naturally and inevitably assumes the horizontal posture from the requirements of its mode of life. It has developed fins as organs of movements. The fin is, in fact, as closely adapted to the fish-form as the oar is to the boat-form. The vertebral fins are reduced in number to four. There is a decided advantage in this reduction, in the saving of muscular exertion needed to move the fin, and also of the weight of extra muscles and fins. But a smaller number than four would be a disadvantage in the varied movements requisite to safety.

The fish-body is necessarily narrow and long, so as best to avoid friction. For its most effective movement it must be properly balanced, its two sides being alike in form and equal in weight. This produces bilateral symmetry of form, and perhaps also of organs, equal weight being most easily and completely attained by a reproduction of organs on the opposite sides of the body, but flexibility and full control of such a long, narrow body could not be gained except by a separate power of motion at each extremity and at each side. Therefore adaptation tends to produce in it four fins, and four only—an anterior and a posterior one on each side.

The fish-form governs that of the amphibian and of the reptile. The fins become limbs, which are variously modified. In some amphibians, as in the frog, the limbs become different in functions, the hind-limbs being adapted to a leaping motion, the fore-limbs to support. A differentiation of another kind takes place, eventually, in the reptile stock, the fore-limbs becoming organs of aërial support. They become wings, and we obtain the bird type, with fore-limbs adapted to aërial, hind-limbs to solid support.

These, however, are but aberrations from the general path of development, which is toward a continuance of the horizontal position of the fish-body: the fins become four similar supporting limbs.

Adaptation from this point takes one general direction, that of the reduction of weight to the lowest point consistent with the proper exercise of the nutritive functions, and the requisite strength of bone and vigor of muscle. The general shape attained by the body is governed by several mutually assisting or opposing functions. The requirement of speed needs that it shall be narrow and long, so as best to avoid the resistance of the air. But too great elongation would be a disadvantage, since the mid regions of the body would remain without support by the limbs, and could only sustain themselves by muscles acting to oppose gravity. These muscles would add to the weight, and would form additional consumers of force. The best form of the body, then, is one sufficiently narrowed to partly avoid aërial resistance, but not so elongated as to diminish its proper support upon the limbs. The chief aberrations from these requirements are those of the prone serpents, and, among mammals, of the weasel family, whose mode of life requires a very narrow body, so that digestive space can only be gained by its elongation. We may return here to the serpents to say that their elongation is probably due in great part to the same cause. Their mode of concealment and of motion requires great narrowness of body, so that space for the nutritive functions can only be gained by elongation. The requirement of narrowness is, in fact, so great that there is not sufficient room for the larger organs to be bilaterally reproduced, therefore respiration is confined to a single lung, the other being atrophied.

But, with a comparatively few exceptions, caused by highly specialized life-habits, the land vertebrates possess the general form requisite for the fullest adaptation to these three conditions—that of reduced resistance to motion, proper support, and the necessary room for the exercise of the nutritive functions.

The weight of the body is reduced to the lowest possible limit consistent with its general size and the exercise of its functions. The limbs, for instance, take no part in the nutritive function, and are reduced in size to the weight of bone requisite for support and of muscle necessary to move the body. The head is just large enough to hold the brain, the organs of special sense, and the mouth with its

organs. The neck is narrowed to a mere covering to the œsophagus, the vertebræ, and the muscles of head-support. Its necessary flexibility is one reason for this, but the cutting off of extra weight wherever it can be spared is another.

Thus, as a general result of these evolutionary principles, we obtain a body of horizontal shape, supported upon four limbs, and reduced in weight and in elongation so as to give it the best possible control of its motions, and the greatest agility consistent with its necessary gravity.

The necessity of quick knowledge of danger and of ready escape from it have had other equally important results. The organs of sight and hearing has been placed at an elevated point, so as best to perceive distant danger, while the limbs of the herbivora have also elongated so as to lift the body to a wider outlook. This elongation of the limbs is also an important adjunct to rapid flight, so that there are two forces at work upon its development.

In the carnivora, on the contrary, the crouching, springing habits have tended to shorten the limbs, and to adapt them to vigorous leaps instead of to rapid running movements ; to a life in ambush instead of to a life in action.

But the particular features of the body of the land vertebrate are as closely a result of natural requisites as are its general features. It forms, in a large sense, a digesting and assimilating machine, the force derived from assimilated food being largely applied to the muscular and nervous functions needful to obtain new food, or to avoid danger. Another portion of this force is applied to excretory and reproductive functions. That is all. There is none of the human employment of force in abstract mental conception. All mentality in undomesticated animals is employed in the art of self-preservation.

The organs arise as direct consequences of these necessities. We may view them as partly governed in position and character by their descent from the fish type ; yet such a controlling agency hardly appears, so exactly are the various organs adapted to the life-needs of land-animals.

The digestive function is alike in all animals, and its evolution has ever been in one line, namely, a division of labor so as to secure more perfected results. In the mammalia this separation seems complete. From the masticating teeth to the salivary solvents, the stomach and intestinal digestions, and the intestinal absorption, every distinct portion of the process has gained its separate organ, adapted only to that one duty. The ensuing circulation is similarly specialized, being divided into the blood and the lymphatic circulations, the latter taking up normally the products of digestion and the nutritive products of the waste of the tissues ; the former applying these to the nutrition of the tissues.

A third organic requisite is that of oxidation. This has been vari-

ously performed in animals. In primitive life it acts through the outer skin. In higher forms a portion of this skin becomes adapted to that purpose, as exterior branchiæ. In the Ascidiæ it is performed by the anterior portion of the intestine. In all vertebrates it is an intestinal function, the forward portion of the intestinal tube becoming the gill of the fish. A sac-like ingrowth from the intestine—the swimming-bladder of the fish—becomes the lung of the air-breather. It eventually separates into two portions, and adapts itself more perfectly to a function which it may have partly performed in the fish.

Thus the respiratory function has gradually moved inward to a position of safety, which is only fully attained in the air-breathers. Its position in the anterior, instead of in the mid or the posterior portion of the intestine, has another reason besides that of inheritance. This is its connection with the pulmonary circulation.

In considering the division of labor in the circulation we did not speak of its separation into two distinct portions, the nutritive and the pulmonary portion. This division of function is partly attained in fishes and reptiles, fully only in birds and mammals. And the heart, which serves as a force-pump to drive the blood through the body, becomes here a double pump, one half driving the blood through the arteries, the other half driving it to the lungs, there to become aërated.

The former circulation needs to penetrate the whole body. The latter can be fully performed with little extension of its blood-vessels. And in the labor-saving principle of organs, which hinders any excess of material or of effort, the tendency is to a curtailing of the length of this pulmonary circulation. Natural selection, therefore, acts to bring the heart and the lungs into close contiguity.

But there is another reason for the position of the heart in the anterior portion of the body. Its action as a force-pump renders it an advantage that it should be placed nearest the point where it has most work to perform. Now, the brain receives a much larger percentage of the blood than any similar portion of the body. More force, then, must be exerted by the heart in the direction of the head. If it be so placed that its labor in every direction may be equalized, it should occupy an anterior position.

In quadrupeds this need becomes still stronger, for the blood going to the head has to overcome gravity, that going to the body and limbs is largely aided by gravity. This need is, of course, strongest in man, in whom the requirements of the brain are the greatest, and in whom the upward flow is directly against gravity, the downward flow directly favored by gravity.* But in all the higher animals the heart, and therefore the lungs, necessarily occupy an anterior position.

* Very probably, however, the aid which the arterial downflow of the body circulation receives from gravity is balanced by the resistance of gravity to the venous upflow. And, likewise, in the head circulation the gravitative resistance to the arterial current

Protection of the body is, to a certain extent, secured by its being inclosed in a bony case, the ribs. It may be thought strange that the advantage to be derived from this defensive armor is not extended to the whole body. It very probably would be, were there not some active influence opposing it. This influence may be, the necessity of expansion of the ventral surface. Expansion and contraction in the chest are regular and rhythmical, and are secured by the jointed connection of the ribs with the breastbone. Expansion in the abdomen is irregular and at times excessive. Incasement in an inflexible rib-case would, therefore, prove highly disadvantageous.

Yet no flexible condition can well arise in response to expansions appearing irregularly and often at long intervals. As the ribs, therefore, could not gain, by selective adaptation, the proper motive relations to these occasional expansions, and as inflexible ribs would be a disadvantage, abdominal ribs have failed to appear.

The general characteristics of the body being thus necessarily as we find them, and the position, length, joints, and action of the limbs being inevitable results of their purpose, as the organs of animal motion, it remains to trace the origin of the head with its organs.

The head is simply the carrier of the organs of the special senses. The brain, so far as its secondary action is concerned, might very well be situated in any other portion of the body, but we think it can be shown that the location of the eyes governs that of the brain, and that the head with all its organs is an adjunct of the eyes.

These important organs necessarily occupy the most elevated part of the body. The outlook is better from this location, and the safety of the animal is thus more assured. An anterior location is also highly desirable, as otherwise the forward-moving animal would be in constant peril from obstacles in its path, and would be unable to perceive the prey it was pursuing. Also, as the delicate character and exposure of the eyes tend to limit their number, the portion of the body bearing them must be sufficiently flexible to permit vision in all directions.

All these requirements tend to the production of an anterior, elevated organ mounted on a neck of flexible movement, and as long as is consistent with easy support of the weight of the head. The ears, also, are best situated upon this head organ, and in such a position as to adapt them to catch sound from all directions.

And this position of the eyes and ears necessarily requires the brain, for its fullest effectiveness, to be likewise situated in the head. For the greatest safety follows the quickest warning of danger. But, as is well known, the nerves are slow in their conveyance of sensations. The animal, therefore, whose eyes and ears are nearest the brain be-

and aid to the venous current are equal. But the fact holds good in all vertebrate animals, that the quantity of blood to be driven to the brain exceeds that to be driven to the lower body.

comes most quickly conscious of peril, and will outlive, as a rule, the one whose sensations have a longer distance to travel.

It can be easily shown that the mouth and the organs of taste and smell are as necessarily confined to the head, and that their special location is closely governed by that of the eyes.

For animals have safety of two kinds to provide for, safety from foes and safety from food; external and internal perils. Poisonous or unwholesome food is quite as necessary to be avoided as dangerous foes. The animal that is best protected against this peril has the best chance to survive. So important, indeed, is this necessity, that not alone the sight and the sense of touch and of temperature are on guard against injury from such a source, but two organs of sense, smell and taste, seem specially provided for this purpose alone.

The needful action of the eyes, as food-inspectors for the body, fixes the position of the mouth at such a distance from them that they will unavoidably perceive the food. Animals are not likely to voluntarily examine their food before eating it. They must be forced to do so involuntarily. Therefore, the eyes naturally command the entrance to the mouth, at the best distance for the most acute vision.

The relative positions of eyes and mouth being thus fixed, those of the smell and taste organs follow. Odorous emanations arise from the food significant of its character. The animal becoming most conscious of them has the best chance to escape danger. These odors naturally rise upward. The nose, as the organ of smell, is therefore best situated just above the mouth, and overhanging it, the performance of its function, as the organ of respiration, causing the respired air to sweep the lips and draw in the odors arising from the food.

The organ of taste, on the contrary, is best situated on the rear portion of the tongue, since the food must be masticated by the teeth, and partly dissolved by the saliva, ere it is in condition to excite the sense of taste. It must not be placed so far back, however, as to hinder the rejection of food warned against by the nerves of taste.

The head of the animal, then, seems necessarily to be just as we find it, the seat of the special senses and of the brain; while the relative location of these sense-organs and of the mouth, the position and elevation of the head, and the narrowness and flexibility of the neck, appear to be all necessary adaptations for the most complete protection of the whole organism.

The mammalian body, then, so far as we have yet seen, appears the best adapted of animal forms to gain extended and varied experiences of nature, to become exposed to diversified perils, and to evolve the most complete division of function. This body, once attained, is closely adhered to. While displaying thousands of minor variations, adapting it to special circumstances, it retains unvaryingly all the general characteristics mentioned. This close adherence seems to show that

its form and organic functions are the best of all adaptations attained by the animal world up to that height.

The mammalia have another advantage which we will but glance at here. The young of the mammal has a better start in life than that of any other type of animal. In this direction, also, there has been a constant development in the process of evolution, the young of lower animals being born in an embryo state, and needing to consume force in passing through various degrees of metamorphosis. The young of the mammal is fed by the mother through all the embryological stages, this being most fully performed in the highest mammals, so that their young commence an independent life at a stage to reach which the young of lower animals consume a considerable portion of their vital energy.

Yet, with all these advantages, the mammalian quadruped has not attained the highest position in animal development. It will be very easy to point out several defects in its organization, which detract from its powers as a living body. In the first place it only imperfectly overcomes gravity. Shortened as the body is, a considerable part of its weight is not supported by the limbs, and needs muscular support. This increases weight and uses up force. The head also is not directly supported by the limbs and needs powerful muscular support in the neck. The need of using the teeth as food-grasping instruments requires a forward extension of the head, instead of a vertical position over the fore-limbs.

In division of labor it is likewise defective. Thus its limbs have a double duty to perform—they are used both as organs of motion and as weapons. The herbivora use their hind-limbs for defense, the carnivora use all the limbs as offensive organs. The same may be said of the teeth. The carnivora use them both as weapons of attack and as organs of mastication. The herbivora are frequently supplied with heavy horns as defensive weapons, thus adding to the weight of the head.

Obviously, then, there are a variety of requirements to be supplied ere the most completely developed animal form can be attained. In what direction shall this further development proceed? How shall the above-named disadvantages be obviated? The first steps toward it are made when mammalian animals begin to differentiate the functions of their fore and hind limbs. We have noticed some forms of this differentiation. A more significant form displays itself in those animals which live in trees. Many of these, it is true, use all the limbs alike in climbing, and remain true quadrupeds upon the land-surface; others, as the monkeys, use the fore-limbs as grasping, the hind-limbs as supporting organs, and thus begin to separate them in function.

This separation proceeds with extreme slowness. It is only imperfectly attained in all existing monkeys and apes. For its complete attainment the differentiation must proceed to that degree that the

fore-limbs shall become useful only as grasping, the hind-limbs only as supporting organs. Necessarily, then, the pelvic joint must gradually change its direction from a right angle to a straight line. The complete result, in fact, is only attained when the hind-limbs and the body form a vertical line, the function of support being performed entirely by these limbs, while the fore-limbs are freed for other functions, and so changed as to be specially adapted for grasping.

This desideratum is attained in man, and in man only of all the animal kingdom.

In the human form, then, we find all the advantages possessed by the mammalia as a class, together with certain important features of development not possessed by any other mammalian animal. Perhaps the most important of these is the fact that in man gravitation is overcome with a less expenditure of muscular force than in any other land-animal. The whole weight of the body stands vertically above the organs of support. The muscles which in other animals act as ropes and levers of support are only called upon in man to preserve his vertical position. Evidently much less force is needed to preserve vertical equilibrium than to support horizontal weights.

The head, also, which needs muscular support in quadrupeds, in man presses directly downward upon the common center of gravity. And significantly the complete development of the brain tends to perfect this vertical position, as it yields a rounded and vertically poised head. The head in man has but one set of duties to perform, sensory and masticating labors. The hands bring food to it, instead of its having to seek food; therefore it has no need of the horizontal position and movements found in quadrupeds. Finally, that there shall be no weight needing muscular support, the fore-limbs hang vertically downward, being sustained by bones and tendons instead of muscles.

Support on the hind-limbs releases the fore-limbs to act as the defensive and offensive organs. For their most complete adaptation to this function the position of the shoulder-joint (like that of the pelvic joint) is changed, and the arms become lateral instead of ventral limbs. Finally, the teeth are released from duty as weapons, and are confined to their proper duty as masticating organs.

Thus only in man does the organic division of labor become complete, every function having a separate organ adapted to it alone. And the stores of force are husbanded to a degree not found in any other land-animal, the weight of the body being supported by bones instead of muscles, by adjusting instead of lifting energies.

And in regard to reproduction man surpasses all other animals, except the highest apes, in division of labor and localization of function. The young of the human race thus commence life with the best possible preparation, their vital activity being husbanded so that they enter upon their individual life-work at perhaps a higher starting-point than any other animal.

In organic differentiation, then, man seems to have reached the highest possible point. Also, in avoidance of the constant forces of gravitation and friction, he has almost achieved perfection.* And he starts life with the least expenditure of force in embryological development. In all these respects he seems to have attained the utmost height of organic development.

In respect to his adaptation to the other forces of nature—his powers of sensory perception—he is also in advance of all other animals. Not only is the division of labor of the animal organs within him—the nervous, muscular, and osseous systems—complete, but his exterior sensibility to the impress of force is the most delicate of that of all animals. This is perhaps not the case in the organs of special sense, though the position of the human nose, with its nostrils directly overhanging the mouth, seems a superior adaptation to its duty in the perception of odors. But in regard to the sense of touch, not only has he a superior provision in the tactile organs of the fingers, but the naked and soft condition of the skin renders it susceptible to contact in a degree not possessed by any other animals.

Other animals, in fact, are either covered with a dense coat of hair or feathers for protection from cold, or with a thick leathery or bony skin as armor against danger. In the development of man alone has Nature pursued her most elevated path, increasing his susceptibility to exterior influence, his power of gaining sensible experience of nature, to the utmost possible degree. This is probably the true explanation of the naked condition of the human skin. His mode of life has rendered the fullest perception of nature desirable, and adaptation has consequently taken this direction, removing from his exterior surface everything opposing the utmost sensibility, and, for the same reason, hindering any undue thickening or induration of the outer skin.

Such is man—the extreme upward limit of physical progress in organic nature—the one last step forward which living beings have taken after their long permanence in the quadrupedal stage. And beyond his form no physical progress seems possible, for he fulfills what we conceive to be Nature's design, viz., to husband force by the fullest avoidance of gravity and friction, to decrease weight to the lowest available point consistent with the size and strength necessary to best adapt him to surrounding conditions, and to produce the utmost susceptibility to impression of natural force—to attain a form, in fact, having the greatest excess of available energy, and best adapted to gain experiences of the conditions of nature.

But these very advantages in the human form produce certain un-

* In the prone vertebrate, the serpent, the escape from gravitation is accompanied by a marked increase of friction. In man both gravity and friction are simultaneously decreased to the greatest possible extent. Thus the serpent and man occupy the two poles in the development of motive powers, while all other vertebrates occupy intermediate positions.

avoidable disadvantages. Man's adaptations to the conditions of nature are necessarily limited. Thus it might be supposed that a perfect animal would be adapted to traverse the water and the air, as well as the land. But such an adaptation would require extra organs, extra weight, and extra consumption of force in their support. Man, on the contrary, has become adapted to the highest field of life, and escaped an adaptation to inferior fields which would prove a disadvantage in the struggle for existence with land-animals.

His extreme sensitiveness to exterior influences gained by his naked skin is, of course, a sensitiveness to temperature as well as to touch. He is thus limited organically to tropical regions, and to some extent to a life in the shade—to a forest residence. In fact, he seems more limited in locality and in powers of resistance than most other animals. His unclad skin renders him acutely sensitive to extremes of heat and cold. He has no cortical defense against the attack of his animal foes. His limbs have become adapted to grasping and to support, but have lost their character as offensive weapons. Finally, his adaptation to an arboreal residence has become imperfect. He can not climb like a monkey, run like a deer, swim like an otter, mine like a mole, or crouch like a cat.

Physically, then, man is one of the most poorly protected of animals, seemingly a form not likely to survive in competition with his swift-running, flying, and climbing neighbors, and with his carnivorous foes, armed with tearing claws and rending teeth.

Yet in other respects he has decided advantages. One of these is a feature in which very few animals rival him, a differentiation in his adaptations to nutriment, enabling him to masticate, digest, and assimilate both vegetable and animal food. This is a decided advantage. Man is at once herbivorous and carnivorous, his field of possible food thus being doubled, and his consequent variety of adaptation to nature being likewise doubled. There is no other animal adapted to this double diet to the same degree as man. By a rather unpleasant resemblance, the hog most nearly approaches him in this respect. Yet the hog is principally a vegetable feeder, and only occasionally varies his diet to animal flesh.

A second advantage is the economy of muscular force gained by the vertical attitude. The force thus saved might have been employed in the production of an extreme agility, enabling man to escape danger by speed and alertness. It has fortunately been applied in another direction, that of the production of mental acuteness. From the time that man first employed the grasping power of his hands to seize stick or stone for defense against his foes, a process was begun which is yet far from completion. It was, in its full results, the process of mental evolution. But, for our present purpose, we must give it a more narrow significance.

In all probability man, physically, is not now what he was origi-

nally. The use of the stick or stone in defense set in motion a new process of adaptation which has tended toward a physical weakness, at least in regard to conflict with wild animals.

It was, in fact, the first step in the enhancement of animal force by the employment of the vast stores of inorganic force existing throughout nature. It was the earliest inventive action, the bringing of outer nature to human aid, which has since produced such wonderful results. Muscular vigor and acuteness of sense have probably decreased as they have been thus partly replaced. For man has gained new muscles, in his use of the forms and forces of the inorganic world, and has commenced a new process of adaptation, which has already enabled him to extend his kingdom from the tropic to the frigid zone, and which promises to make him to some extent master of the fields of water and air. And his mental experience of wider and wider conditions of nature has produced a new form of physical adaptation—that signified in clothing and habitation.

But this opens a new subject, too wide to be considered here. We can only end as we began, with the assertion that the human form occupies the apex of possible organic development, and forms the true foundation for that higher mental evolution which is still growing, branching, and flowering upward.

THE RELATIVE HARDINESS OF PLANTS.

By SAMUEL PARSONS, Jr.

THE isothermal line, curving up and down the map, is no inapt illustration of the course another line would take on the chart which sought to explain the relative hardiness of plants, only the curves of the latter would be more complex than those of the former. Who, indeed, could direct aright such a line for even individual species? and for varieties it would be wellnigh impossible. Scarcely could reliable data be furnished for the broader division of genera. And yet the investigation that does not take into account varieties misses a large number of plants possessed of the most noteworthy and valuable individual traits. The question may be easily asked, Wherein lies the difference between a variety and a species? but the answer evidently is not so easy, when we consider that every individual plant varies in a degree from all other plants; and, to render it still more difficult, we find botanists very properly ignoring the existence of varieties that may have individual characteristics invaluable to the planter.

Latitude, moreover, we find is only one factor, and a very vague one, in the problem of determining the relative hardiness of plants. Climate is the real governing element—climate, that varies with the

special conditions of every valley and hill-top. Yet the knowledge and insight that determine the relative hardiness of plants seem easy of acquisition in the eyes of the inexperienced. Still, no one, really an expert in such matters, will venture to express a decided opinion on such data as are usually obtainable. A canny Scot of our acquaintance, whose knowledge of plants in a practical way is encyclopedic—if such a term in such a connection be admissible—is a notable example of this wise cautiousness. Never was he known to positively commit himself, at least on the subject of the peculiarities of plants. "They might be hardy," he would say, "and again they might not. Circumstances alter cases." There was always a profound consideration shown for the incalculable effects of any particular environment.

That we may better realize the strangely complex character of the relative hardiness of plants, let us consider briefly the special behavior of various kinds under apparently similar conditions, and then note with care their behavior under evidently different conditions. Take Japanese plants, for instance. They illustrate how, sometimes, on two sides of the globe, in the same latitude, almost identical species and varieties appear. Whether it is the similarity of the course of the oceanic currents along their shores and the trend of the mountain-ranges inland that modify the two climates into a peculiar likeness, or still more recondite causes, the fact remains that whole genera of Japanese plants resemble in the strangest way indigenous American kinds. Retinosporas, the most popular evergreens of Japan, seem, in some cases, though confessedly distinct botanically, nearly identical in appearance with Thujas or American arbor-vitæs, and they also behave alike. In grafting, for instance, members of one genus require members of the same genus as stocks. Yet the Retinosporas, which graft well, of course, on their own stock, graft also with entire success on the American arbor-vitæ, which the botanist tells us is an entirely distinct genus. They are, likewise, equally hardy, but the variation in form and color, in both Japan and America, is much greater among Retinosporas than among American arbor-vitæs. This capacity for endurance of like conditions which appears among Japanese and Eastern American evergreens runs also through deciduous trees. There are maples on the Amoor River and in Japan which have little to distinguish them from at least one variety of maples in America, and there is a similar kinship in reference to hardiness.

These instances of resemblances in hardiness and in other features, between plants botanically widely different, might be greatly multiplied, but those mentioned will suffice to show the widespread likeness, in these respects, of many different plants throughout the globe. In face of these extraordinary instances of similarity in hardiness of plants the native haunts of which are widely removed, we have to recognize the existence of many kinds in the same region, closely related botanically, and yet entirely different in their several degrees of hardi-

ness. One of the salient instances of diversity in hardiness of nearly related plants is the behavior of Japanese persimmons in this country. It was confidently expected that they would prove hardy in America, because native persimmons were hardy, and because the general hardiness of Japanese plants in America had been often demonstrated.

But fifteen years' trial of a few detached plants, and five years' trial of thousands together of these Japanese persimmons, prove their hardiness more uncertain than that of the American persimmon. What shall we say of the other Japanese plants that fail to prove hardy in America north of Tennessee, or even Florida—of the Osmanthuses, best described as resembling the hollies in appearance, of the privets, live-oaks, Aucubas, etc.? They are common enough plants in our greenhouses, but only in very sheltered positions, and during mild winters, will any of them live uninjured in this climate. Such facts must be very perplexing to any theorist who attempts to explain why and where this or that plant is hardy.

Or let us change somewhat our problem, and consider why plants belonging to countries much nearer home than Japan, but in similar latitude, fail to prove as hardy here as many Japanese plants. Note the fact, moreover, that these trees I shall next refer to come from even colder regions than Japan, and yet Japanese plants of the same genera are usually more hardy. The ways of plants, verily, become still more puzzling when we find such evergreens as *Thuiopsis borealis* and *Thuja gigantea*, natives of northern Oregon, fail even under the best treatment sometimes, during winters of New York and Philadelphia. Some explanation may of course be attempted by adducing the peculiar climate of the Pacific coast in its rainy seasons, but then consider that many of these plants are found eight and ten thousand feet up in the mountains, and also that, when we pass a few hundred miles farther east in the same parallel of latitude, we find the same varieties and even species such as the Douglas fir becoming hardier. Few, comparatively, of the California native deciduous trees are hardy in the East, and even for many Oregon trees of the same class, such as *Acer macrophyllum*, there is much suffering in store during hard winters on the Atlantic coast. Passing over to Northern Europe, the behavior of trees is still more perplexing. To be sure, as a rule, the Gulf Stream insures milder climate in the same degree of latitude, but away up in northern Scotland, and even in Norway, we find many evergreens more hardy than in the more temperate latitude of New England. Rhododendrons, hollies, and all evergreen shrubs, if not all evergreen trees, do better there, which is doubtless to be attributed in part to a moister climate and more equable temperature, but it can hardly be that altogether. On the other hand, what can we say to the evergreen *Thuiopsis Standishii* doing better here than in England, and *Thuiopsis dolobrata* better in England than in America? Japanese maples, that seem to grow more thriftily and vigorously here than in Japan, give evidence

also of being less adapted to England than to the United States. Besides, why is it that evergreens thrive better, and are more hardy, in a cultivated state in Europe, and deciduous trees in this country? We know answers can be given by experienced observers to all these questions, that are more or less comprehensive, but we believe also that, when such answers come to be closely scanned, it will be found that they do not entirely meet the case. How is it, otherwise, that the same peculiarities in a minor degree are evident in the behavior of trees growing within a few miles of each other? One might understand why the same plants act differently farther inland, but here in the neighborhood of the coast it naturally strikes us as curious that on the Hudson River some plants are hardier than on Long Island.

There are more inexplicable facts than these. Mr. Hunnewell can grow plants on his lawn that will hardly live through some winters, even under the most favorable conditions, on any other spot about Boston.

Nor is this the strangest feature to be noticed in the behavior of plants under apparently like influences of soil and climate. Plants a few feet from each other, of the same species, will suffer in very different degrees during many winters. Rhododendrons are a notable instance of this. It is not simply that *Rhododendron ponticum* and its hybrids are not as hardy as *Rhododendron Catawbiense*, nor that the more of the Catawbiense strain there is in a Ponticum hybrid, the hardier it is, but it is that sometimes a Ponticum hybrid, usually entirely unreliable, will pass the winter unscathed, when nearly the hardiest pure Catawbiense of the plantation will be killed. But our expert says, "One did not ripen its wood as well as the other." Yes, but is it not also strange that sometimes the one which finally died was the one that had ripened its wood most thoroughly?

A few striking examples like these should be sufficient to illustrate the great difficulty that must always attend the determination of the relative hardiness of plants. Many more instances of the same character might be readily selected, but it is not necessary. We have simply endeavored to give sufficient data to warrant the general statement that the varying and complex conditions of the environment of any given plant are difficult to understand or explain on the basis of experience of another environment which, to a superficial observer, may seem to be identical with the first. Our intention is not to insist on any explanation of the facts adduced in regard to the relative hardiness of plants, but only to show distinctly the difficulties that must attend such explanations, and to point out that experience is now being purchased too dearly, and that it is, moreover, not of a sufficiently varied character. Hundreds and thousands of plants are killed every year under very similar circumstances, and it seems evident that human intelligence should be sufficient to compass some method of reducing this loss to a minimum.

The Cambridge Botanic Garden and the Arnold Arboretum, adjoining the Bussy Institute, being well organized and both managed under the auspices of Harvard College, would be perhaps the best repository of reports on the relative hardiness of plants.

The proper sources of these reports would be botanic gardens such as those of Washington and Cambridge, and parks such as those of New York and Philadelphia, the superintendents and gardeners of which might be directed to make careful investigations and fill up printed forms month by month on the behavior of plants in different localities. Above all, private individuals—and they need not be trained observers—all over the country should be encouraged to investigate in the same systematic way and report to the central repository. Consider how valuable such records of actual hardiness would be, coming from interested observers everywhere, if the resultant tables were published in a compact form! The perplexing question of the behavior of rhododendrons, for instance, would probably be explained, whereas twenty-five years of unsystematic observation has been very barren of results.

It may not be out of place in conclusion to say a word concerning the so-called acclimatization of plants. The name seems to imply the use of some peculiar treatment whereby a half-hardy plant is made hardy. There are many people who really fancy that tender plants may be rendered hardy by first protecting them carefully and then exposing them more and more by degrees until they are taught to endure a manifestly greater amount of cold than they did at first. Natural selection carried on for hundreds and thousands of years may accomplish a change of nature of this sort, but, under ordinary limitations of time, the attempt to acclimatize, in this sense, is practically futile.

WHAT IS A COLD?

By A MEDICAL MAN.

TO enjoy life, one must be in good health; and to remain free from disease is the desire of all. Yet there are some ailments which do not interfere very much with the pleasures of life, and therefore are not dreaded in consequence—nay, more, they are frequently treated with neglect, although in many instances they are the precursors of more serious disorders, which may in not a few cases have a fatal termination! How often, to the usual greetings which one friend exchanges with another, is the reply given, "Very well, thank you, except a little cold." A little cold, and yet how significant this may be! In how many cases do we find a "little cold" resemble a little seed, which may sooner or later develop into a mighty tree! A little

cold neglected may, and frequently does, prove itself to be a thing not to be trifled with. Let me, then, pray my readers to remember that small beginnings in not a few instances have big endings, and this especially where disease exists. Let us, then, consider what is a common cold.

In the first place, we must be paradoxical, and affirm that it is not a cold at all. It is rather a heat, if I may so express myself, that is, it is a form of fever, but, of course, of a very mild type when it is uncomplicated by other diseases. It is certainly in the majority of instances due to the effects of cold playing upon some portion of the body, and reacting upon the mucous membrane through the intervention of the nervous apparatus. What is called a cold, then, is in reality a fever; and, though in the majority of instances it is of such a trivial nature as to necessitate few precautions being taken during its attack, yet in some cases it runs a most acute course, and may be followed by great prostration. Even when the premonitory symptoms of a cold are developing themselves, when, for example, what a medical man calls a rigor, or, as it is popularly designated, a shivering is felt, when we would naturally suppose that the animal temperature is below par, it is at that very moment higher than the normal, thus showing the onset of fever.

Before going at once into the symptoms and nature of the disease under discussion, it will be advisable to dip a little into that most interesting department of medical science, physiology, and, indeed, without doing so, it would be quite impossible for the majority of my readers to understand the manner in which cold acts in producing the inflammatory condition of the mucous membrane of the nose, or, as it is called, the Schneiderian membrane, which inflamed condition constitutes a cold in the head. It will be necessary to understand what a mucous membrane is, what its duties are, and how these duties are performed, before entering upon a description of a disease attacking it. To take the mucous membrane of the nose as an example. We find that it is a membrane spread out over a very large area, lining as it does a great many undulations caused by the arrangement of the bones composing the walls of the nostrils, so that a very much greater surface is required to be traversed by the air entering the lungs through the nose—the natural passage—than is required by the actual length of the canal. The object of this is obvious, when we take into account the fact that the temperature of the air is usually either below or above that of the human body, and that it is almost invariably loaded with particles of matter which would irritate the lungs did they find access to them.

The tortuous passage of the nose thus tends in the first place to equalize in some measure the temperature of the atmosphere inhaled with that of the lungs; and, in the second place, the mucus which is secreted by the Schneiderian membrane, being of a tenacious nature,

tends to attract and ensnare the impurities which the air may contain. We thus see that the nostrils act as a filter to the air taken in by inhalation. If we observe any mucous surface, we can not help remarking its deep-red color, this being due to the close network of blood-vessels ramifying on its surface. In consequence of this accumulation of minute arteries and veins through which warm blood is constantly flowing, a pretty high temperature is constantly maintained in any cavity lined by mucous membrane. There is, therefore, little difficulty in understanding how important a part the nostrils play in preparing the air for its entrance into the sensitive structure of the lungs. But the nostrils do not only temper the air—they also yield to it an amount of moisture which renders it still more bland and less irritating. We see, then, that the functions of the nostrils as regards the atmosphere inhaled are threefold: 1. In equalizing its temperature; 2. In moistening; and, 3. In filtering it. The latter function is materially aided by quite a forest of minute hairs which guard the entrance to the passages.

Having noticed how distended the blood-vessels of the mucous membrane naturally are, it will not be difficult to understand how slight a disturbance of the balance of blood-supply will be necessary to produce congestion or inflammation of the structure, and such is really the case; and it is because of this that people who have what is called an irritable mucous membrane are so susceptible of cold. They have, in fact, a chronically congested mucous membrane, which, however, is usually associated with and dependent upon a disordered digestion. Yet, notwithstanding these facts, a cold is not produced by cold air acting upon the surface which suffers. It is quite true that there are individuals with peculiar idiosyncrasies who take catarrh when they smell certain substances. For instance, many can not go into a room where powdered ipecac is exposed without immediately catching catarrh in the nasal passages; and there is reported the case of a man who could not smell a rose without being affected in a similar way.

We must now go a step further before we can understand the *modus operandi* by which a cold in the head, or any other region, is produced. It has been shown that one of the functions of a mucous membrane is to secrete mucus. But what is it that makes the secretion vary in quantity? Well, an irritant applied directly to the surface may produce an excessive flow, and this superabundance of mucus is thrown out by an effort of nature in its endeavor to shield the delicate membrane and remove the irritant; this may happen also when there is an excessive amount of blood in the vessels, which is the case when congestion exists, the distention of the blood-vessels acting as an irritant, and supplying in greater amount the fluid from which the mucus is extracted, thus tending to excite the secreting power to greater effort. Thus we have an explanation of the excessive discharge in catarrh of the nose. But, when the direct irritant is removed, the

unnaturally abundant discharge ceases. Not so, however, when the superabundance is due to the effects of cold; for, in the latter case, a diseased condition is set up, which will only disappear when the effects of the exposure upon the nervous system have passed away.

Having demonstrated that cold is not produced by the action of cold air playing upon the part affected, but that, on the contrary, it is an effect of cold acting upon a distant part of the body, it will be necessary to explain how this is brought about. If a person sits in a draught of cold air, and this draught is directed upon the back of his head, the chances are that a catarrh of the nasal passages will result, and this is produced by what is called reflex action of the nerves. Here it will be necessary to diverge a little, and explain what reflex action is. It must be understood, then, that there are numerous nervous centers connected with the spinal cord. These nervous centers send filaments of their nerves to various portions of the body. For example, a nerve-center may be placed alongside the spine in the neck, and from this point nerves may be distributed to the back of the head and the mucous membrane of the nose. One important function of these little bodies is to control the supply of blood to different surfaces and tissues and organs. This is done by a system of minute nerves which are distributed on the arteries, by which the vessels are kept in a state of contraction. Now, if these nerves are severed from the main trunk, the blood-vessels immediately expand to the full extent of their caliber, and congestion is the result; or, if these nerves are paralyzed, the same effect is produced. Sometimes a very slight shock produces a temporary paralysis of these minute nerves when a rush of blood takes place into the arteries, of which blushing is a good example; but the nerves soon recover their control over the blood-supply, and the blush passes away. Then, again, the shock may produce quite the opposite effect: this may be so severe as to cause such extreme contraction of the blood-vessels that a deadly pallor pervades the face, as, for instance, in severe shock from fear. This, however, is caused more by the effect of shock acting upon the nerve-centers which supply the heart with motor power.

But let us suppose that one extremity of a nerve arising from a particular nerve-center is irritated; this is communicated to that center, which is affected thereby, it may be slightly or more severely. The irritation may be so great as to prostrate for the time being the nerve-center, and, in consequence, all the nerves arising from it are thrown into a state of inaction. This is called the reflex action of that nerve-center, because the effects of the irritant applied to one part of the body are thereby reflected to other parts. Instances of reflex action may be seen frequently in every-day life. Take, for example, the action of the eyelid when an object threatens to enter the eye. The retina perceives the object advancing; this is telegraphed to the nervous center supplying the muscles which open and shut the eyelids,

and immediately a message is sent back to the eyelids to shut, and exclude the particle of matter that threatens to enter the eye. All this is done so quickly that it is hardly possible to realize that there is time for reflex nervous action being brought into play.

Another instance of reflex action, but this time influencing the secretions, may be cited. Who is not familiar with the effect of a savory smell, or the sight of some luxury, upon the salivary secretion, so that, to use a common expression, "the mouth waters"? In the first, the olfactory nerve is the means by which the impression is conveyed to the nerve-center; in the other it is the optic nerve which is the transmitting agent; but in each case the impression is reflected to that nerve controlling the salivary secretion, with the effect of producing an increased flow of saliva. We thus see that the secretions can be influenced by one nerve conveying its impression to another whose filaments take origin in a common center.

Now, to come to the subject more directly under consideration in this paper, we must comprehend how cold acting on one part of the body produces catarrh of the nasal mucous membrane. Exposure to the most intense cold for a lengthened period will not produce this effect. Indeed, we find it invariably the case that severe frost in winter is, so far as catarrh is concerned, the healthiest weather we can have. During the prevalence of frost, as a rule, colds are at a minimum. The system here shows its power of accommodating itself to the circumstances surrounding it, and actually benefits by the prevailing low temperature. Let us, however, suppose a person to be sitting in a room the temperature of which is, say, 70° Fahrenheit, and that a current of cold air is rushing in at an open door or window, and playing upon the back of his head, or it may be on his legs or feet, and the probability is that he will "catch cold," and in nine cases out of ten this cold will be a catarrh in the head, and, what may appear more remarkable still, only one nostril will at first be affected. Now, if the catarrh was due to the inhalation of cold air, both nostrils would suffer; but it is not so; for, as each side of the body is supplied by its distinct set of nerves, so only that side is affected through which the reflex disturbance has been transmitted. The *modus operandi* is the following: The draught of cold air, acting, we will suppose, on the back of the head, conveys through the sympathetic nerve, which ramifies on the scalp, a shock to the nervous center from which these nerve-fibers proceed; but we must understand that this nerve-center sends its filaments to other portions of the body, and so the shock which this center receives by one set of nerves is reflected by another set to some surface quite remote from that primarily acted upon, and in this way a temporary paralysis of the nerves supplying the blood-vessels of the mucous membrane of the nose is brought about. In consequence, these vessels become dilated and engorged, and the shock which has brought about this congestion continuing, disturbs the

equilibrium of the blood-supply, and so an inflammatory condition is set up. When this exists the blood-vessels are enormously distended; consequently, an excess of blood passes through the part, the little cells which secrete the mucus being thus excited and working much more rapidly than when in health. In this way the enormous discharge of mucus, which accompanies a cold in the head, is accounted for.

Another effect of this irritation of the mucous membrane is sneezing, which is an effort of Nature to restore the equilibrium of the nervous center by another kind of reflex action. Sneezing in catarrh is a method Nature adopts to stimulate the prostrate nervous center, and thus enable it to reassert its proper control over the blood-supply to the part; indeed, it will be found that the effects of being exposed to a draught of cold air are often completely destroyed by a succession of sneezes. Of course, Nature does not always immediately succeed in these efforts; but, when she does not, the shock from which the nervous center suffers gradually passes away, and the blood-vessels again come under the control of the little nerves which regulate their caliber, and so the catarrh disappears in a few hours, or at most in a few days. It sometimes happens that the shock from the cold air acting upon the nervous center is of such severity that the consequent inflammation is intense enough to check the secretion of mucus altogether, and in consequence the mucous membrane is dry as well as inflamed, and the suffering very much intensified.

So far, we have only glanced at a cold in the head which passes away in a few hours, but this is not always the happy termination. There is a peculiar tendency which inflammation possesses of not leaving off where it commenced, but of invading the tissues in its immediate neighborhood, and more especially when the tissue is continuous with that primarily attacked, as is the case with the mucous membrane of the air-passages. A cold may commence in the head, and rapidly spread by what is technically termed continuity of tissue into the chest; and so what at the first promised to be only cold in the head may terminate in an attack of bronchitis, or even inflammation of the lungs.—*Chambers's Journal.*

THE PURIFICATION OF SEWER-WATERS.*

By M. E. AUBREY-VITET.

THE sewers of Paris discharge 262,646 cubic metres of liquid matter every twenty-four hours. It is estimated that the quantity discharged will be increased before many years to 300,000 cubic metres daily. Each cubic metre of liquid contains two and a half

* Translated and abridged from the "Revue des Deux Mondes."

kilogrammes of solid matter, of which one kilogramme and a half is merely in suspension. This stuff, flowing into the Seine, causes an accumulation of 116,000 cubic metres of mud in a year at the mouths of the conduits, and makes necessary for its removal an annual expenditure of nearly 200,000 francs. Even this sum is not adequate for the purpose. Far from securing the removal of the obstruction, it is not even sufficient to prevent a continued accumulation, and the muddy deposits are constantly extending farther down the river, and at the same time becoming thicker. Since 1875 they have become about a yard thick, and occupy nearly a quarter of the bed of the river from Asnières to beyond Chatou. The Seine has, moreover, been made foul, and its waters have become unfit for domestic use, poisonous to fishes, and a source of fetid emanations.

The authorities of Paris have been for many years considering measures to remove these sources of impurity from the river. As they are rich in fertilizing matters, the thought was suggested that they might be turned to good account for purposes of agriculture. It was therefore resolved to apply them to works of irrigation in the peninsula of Gennevilliers, where, passing through the thin soil of red earth underlaid with gravel, they might leave their rich manures on the arid land, and be returned to the Seine purified. Five hectares (twelve and a half acres) of land were chosen to be irrigated by the sewer-water, which was conducted in trenches around garden-beds. These lands in return produced abundant crops of the coarser vegetables. Three years afterward, in 1869, independent gardeners began to take in the sewer-water, and the demand for it increased, so that, in 1876, 115 hectares were irrigated, and in 1880 more than 300 hectares. Had the use of the sewage-water as a fertilizing material been the only condition to be fulfilled, the success might have been pronounced complete. The principal object, however, was the purification of the Seine, and in this only the most insignificant result was obtained; for the gardens were capable of taking only a minute fraction of the sewage that had to be disposed of. Complaints of bad effects upon health were increased rather than diminished, so that, in 1875, the Minister of Public Works appointed a commission to devise some means of remedying the unpleasant situation.

A plan was submitted by eminent engineers, under which it was believed the Seine could be definitely relieved of the noxious substances which were defiling it. This plan contemplated the convection, by means of new machinery and conduits which were to be constructed for the purpose, of the foul waters to the peninsula of St. Germain, where it was thought 6,300 hectares of land might be applied to the reception and disposition of them. Of this tract, 1,500 hectares of denuded and sterile land in the forest of St. Germain might be employed as a place of deposit, where the sewage that was not used in irrigation could be turned on and absorbed into the ground, for it was

foreseen that the use of the water would not be uniform, and that in certain weathers and seasons the cultivators would be as anxious to keep it off from their lands as they would be at other times to draw it on. This proposition brought out a general protest. The region which it was proposed to irrigate was largely occupied with country-seats whose proprietors did not at all relish the introduction of the objectionable matter so near their homes. Additional force was given to their objections by reports that Gennevilliers had become subject to infiltration of the waters, and afflicted with fevers generated by them. The project was withdrawn for a time, but was eventually renewed, with the feature of irrigation omitted. In its modified form, it contemplated only the employment of the 1,500 hectares of the forest of St. Germain as a reservoir, on which the sewage-matter should be turned to be absorbed in the ground. This proposition aroused a more determined resistance than the others. Those who lived along the line of the proposed conduit apprehended that the foul waters might at some time be turned upon their own land ; the residents of the neighborhood of the forest regarded with dismay the establishment at their doors of a vast cesspool in the shape of a tract of land which should be covered daily with nearly 200 cubic metres of water, with 60,000 or 70,000 cubic metres of nastiness in a year. The plan is, moreover, defective, for it is not capable of satisfying either of the conditions which are had in view.

The conditions which are essential to a complete solution of the problem must provide for the purification of the sewage and the preservation of the river from contamination with it, and for the utilization of the rich manures which are contained in the waters. The former condition, in fact, is imposed as an absolute necessity ; while the abandonment of the second would only constitute a certain economical loss. Irrigation is really contemplated only as one of the means to the end ; but it is a very inadequate means, for its successful adaptation to the chief purpose would require the employment of a larger quantity of land than it is practicable to obtain for the disposal of the sewage of a large city. A city of ten or twenty thousand inhabitants might with comparatively little trouble find the three hundred or five hundred acres in its vicinity which would be requisite for this purpose ; but, with a city twice as large, the problem is more complicated, while, in a metropolis, it becomes impossible of solution.

Sewage-water, when used for irrigation, is undoubtedly rendered innocuous. It might seem at first sight feasible to combine the two operations, so as to accomplish both objects at once. There is, however, an essential difference in the conditions required for the two solutions which makes the combination impracticable. Ten or twenty times as much land would be required to utilize the waters by irrigation as would be needed simply to absorb the foul matter and cause it to be destroyed by slow oxidation. Thus, the 1,500 hectares of the

forest of St. Germain would be as efficacious, if their action merely as an absorbing medium is contemplated, as 40,000 or 60,000 hectares would be in a scheme for irrigation. The demand for the water under the operations of irrigation would necessarily be very fluctuating. None would be wanted in the winter or in hot weather. While green crops might require much during the whole season of their growth, grain-crops must be carefully protected against it as the season of their ripening approaches. What is to be done with the constantly accumulating supplies of waste water during these seasons when it can not be used?

The whole difficulty arises from the fact that the fertilizing matter which we wish to make useful is drowned in an excess of water. It is this excess which renders sewage unfit for the fertilization of cereals, crops which are too often injured by the superabundance of rain-water. And it is the same excess which makes it impossible to find sufficient surfaces on which it can all be employed in the cultivation of kitchen-garden vegetables, with whose demands its organic constituents well agree. Were this matter extracted in a dry state, it would furnish a precious element of fertilization to a large agricultural interest; and we might preserve it without difficulty and without loss, and transport it at will to apply it to crops of all kinds. At the same time, the water in which it is held could be returned clear and wholesome to the rivers, whose salubrity it is now destroying. Clearly, there can be no discrepancy in the conditions required for the accomplishment of this double object; whatever favors one side must be equally favorable to the other. The two results are absolutely concordant, and may be produced at the same time by one and the same operation, an operation which we may call decantation. The practicability of this process is established by the fact that it has been adopted and is employed with complete success in a large factory in the neighborhood of Paris.

The paper-mill of Essonnes has to deal with 10,000 cubic metres of foul water a day. For two years it has returned to the river Essonnes these 10,000 cubic metres of water clarified, while it has at the same time extracted the mud which they held, and delivered it in a solid state as manure to the agriculturists of the neighborhood.

The apparatus employed at this establishment is composed of two parts, corresponding with two very distinct phases of the operations:

First, is a series of water-tight basins, or tanks, which are used in the decantation, properly so called, of the foul waters.

Second, is arranged a series of tanks having permeable bottoms, constructed parallel with the former tanks, but on a lower level; these are destined for the drainage of the mud which is deposited in the decanting-vats.

The process is as follows: The foul waters from the factory are drawn into a single conduit from about twenty inches to two feet wide, along and over which is disposed a series of circular bucking-

tubs, containing lime-water, a substance which is known to be very efficient in securing the precipitation of organic matters. The tubs are provided with dashers, which keep the lime-water constantly in suspension, and with gauged faucets, which permit it to be introduced regularly in the proportion of two hundred to two hundred and fifty grammes of lime to the cubic metre of water into the current of foul water which is flowing at the foot of the tubs. A few eddies produced by means of artificial obstacles placed in the conduit secure immediately a complete mixture of the lime with the foul water. As soon as the lime-water is introduced, the waste waters almost wholly lose their offensive odor, and cease to offer the slightest danger from noxious exhalations.

The water having been thus prepared in its passage through the conduit, is distributed into ten basins of decantation, each about sixty-five feet long, twenty feet wide, and five and a half feet deep, which are arranged side by side. Each of the basins has a capacity for the decantation of a thousand cubic metres of liquid a day. The water is constantly entering at one end in each, and flowing out over the top at the other end. The rate of flow is almost imperceptible, being hardly a millimetre a second, and precipitation takes place as completely as if the water were quite still; consequently, the water goes out fully clarified. Thus a course of about sixty-five feet in length, which, at the rate of ·001 of a metre a second, represents a delay of nearly six hours in the basin, suffices to clear the water of all matters in suspension. A talus of mud is gradually formed in the bottom of the tank, which at the end of a week becomes flush with the surface of the water at the entrance-end, and just covers the bottom at the end of the outlet. The basin has now produced all the effect of which it is capable. If any more water is allowed to go through it, it will contain mud in suspension, for it is still in the act of precipitating it when it goes out. The operation must be stopped here. We close the feeding-gate of the tank, draw off the clear water that is left in it by means of a decanting-tube, and lay bare the talus of mud.

The bottom of the basin is slightly inclined in a contrary direction to the course of the water, and is provided with a large valve at the lower end. On opening this valve, the mud, which is still in a very liquid condition, is passed into a lower basin—the drainage-basin—of the same capacity as the former one, and so disposed that its upper surface is a little below the bottom of the same. The first tank may be put in operation again immediately after the mud has been drawn from it.

The side-walls of the drainage-basin are of tight masonry, but the bottom is made as permeable as possible. For this purpose a floor of scoria is prepared and provided with a series of pipes which lead the water out into a collector. The arrangement is admirably adapted to the purpose for which it is designed, and quite obviates the diffi-

culty of drying the mud fast enough to enable it to be taken away at a profit, which has prevented the success of all previous efforts at purification by deposition. The mud which is spread on the permeable bottom does not soil the scoria, but leaves it perfectly clean, while the water flows clear from the end of the drains. After two or three days, according to the weather, the mud will appear cracked at some points, and finally over the whole surface. After a week it will have acquired consistency enough to be cut with a shovel. A cart is then brought into the basin, and after a few hours it is emptied and is ready to receive a new charge of mud. The scoria not having been soiled, requires no cleaning, and will be as ready for use even after the end of ten operations as at the beginning.

The drained mud is carried in the shape of large lumps to an open yard, where it is dried in the air without giving forth any odor. It contains about seventy-five per cent. in weight of water at the time it leaves the basin, but the amount of water is reduced after two or three months of exposure to not more than fifteen or twenty per cent.

These operations are of the simplest character, and involve nothing cumbrous. The whole system, with its decanting and drainage tanks, its open yard and the necessary roads, occupies a surface of not more than two hectares, or five acres, for the effective purification of 10,000 cubic metres of water every twenty-four hours. Paris has to get rid of thirty times as much foul water as the Essonnes paper-mill, or 300,000 instead of 10,000 cubic metres a day. The system practiced at Essonnes would, therefore, have to be applied on a scale thirty times as large to be adapted to the needs of Paris. Can it be made to succeed on such a scale? What is there to prevent it?

No difficulty is offered by the composition of the sewer-waters. We have procured a quantity of water from the great collector of Asnières, and have subjected it to the same treatment that is given the waste water at Essonnes. On adding to it lime-water in the proportion of 250 grammes of lime—yes, even in the smaller proportions of 200 and 175 grammes—to a cubic metre of water, a complete precipitation was promptly produced. At the end of four or five hours the water became clear and limpid.

The extent of land required to conduct the operations of decantation, drainage, and drying, on the scale demanded by the city of Paris, seems formidable at the first sight, but it is not really so. As we have seen, the whole system at Essonnes occupies only two hectares, or five acres, of land. For the city of Paris thirty times as much land, sixty hectares, only 150 acres, would be needed to give room for all the apparatus and all the manipulations; that would be a small tract compared with the 1,500 hectares, or 3,750 acres, on which it is proposed to establish a nuisance in the forest of St. Germain.

The scheme will compare favorably with any other that has been proposed, in the cost of constructing and operating the works. The

tanks, occupying six hectares, or fifteen acres, would have to be built up with walls of solid masonry, at an expense of about 1,200,000 francs. A similar sum may be added for the installation of the roads, ways, carts, and other accessories, making a total of about 2,500,000 francs, or $500,000—a mere drop in the budget of the city of Paris. The expense of labor at Essonnes is twenty francs a day; at thirty times as much, it would be 600 francs, or $120, a day at Paris. Add to this the expense of carrying away the manure, in case no return is derived from sales, and the price of the daily supply of lime, estimated at the highest probable figures, and the whole daily expense of operation at Paris rises to 3,000 francs, or $600. The year's aggregate of these daily expenses, with the interest on the cost of original establishment (which we now place, to cover all possible additions, at double the amount of the estimate we have just made), gives the total cost of the application of the Essonnes system to the purification of the sewer waters of Paris at 1,345,000 francs, or about $260,000, a year. The cost of managing the proposed works for the absorption of the sewage in the forest of St. Germain is estimated at 2,120,000 francs, or about $403,000, a year, showing a difference of more than $140,000 a year in favor of the plan of desiccation as pursued at Essonnes.

The difference in favor of this plan is much greater than appears from these figures, for no account has been taken of the probable economic value of the desiccated mud as manure. By actual analysis this mud has been found to contain from eleven to fifteen grammes of nitrogenous substances, and from twenty to twenty-five grammes of phosphate of lime, per cubic metre. The whole deposit from a year's sewage of Paris would contain nitrogenous matters enough to suffice for the fertilization of 75,000 acres of land. It is certain that a sale would be gradually found for this valuable matter, the proceeds of which, estimated eventually to amount possibly to 1,500,000 francs a year, would in the end more than defray the entire cost of maintaining the system of extraction.

MR. FRANK BUCKLAND.

By SPENCER WALPOLE.

EVENTS, in the present time, follow one another with such rapidity, and the favorites of society pass in such constant succession over the stage, that the most startling occurrences are only regarded as nine days' wonders; and men who have even filled a prominent place are almost forgotten before a monument is erected to their memory. Under such circumstances it may prove an almost hopeless task to recall attention to the character of a man who held only a com-

paratively subordinate official position, and who has left no first-rate work behind him to illustrate the achievements of a singularly ready pen. Yet Mr. Frank Buckland occupied so exceptional a position, and held it so long, that common justice requires that his memory should be preserved ; and a short article on his doings, on his character, and even on the eccentricities which formed part of his character, may be welcome to hundreds of persons who knew and loved the man, and to thousands of other persons who did not know the man but loved his writings.

Francis Trevelyan Buckland was the eldest son of the Very Reverend William Buckland, the founder of the modern school of geology, the author of one of the best known of the Bridgewater Treatises, and Dean of Westminster. His mother—Miss Morland before her marriage—threw herself into the geological researches which made her husband famous, and frequently proved a ready assistant to the Dean. His father was probably one of the most popular lecturers ever known at Oxford. With the zeal of an enthusiast, he never confined his teachings to the lecture-room, but frequently organized parties to scour the neighborhood of the university, and explained the geology of the district standing on the very stones on which he was commenting. He had the rare art of throwing interest into the most abstruse subjects ; and stories are still told of him, to illustrate his ready wit, which would enliven any article. In 1826, when his eldest son was born, he had already acquired a considerable reputation ; and he chose as sponsors for his boy two men who both filled some position in the world—Sir Francis Chantrey, the sculptor, and Sir Walter Trevelyan, the apostle of temperance. The boy owed his two names, Francis Trevelyan, to his two godfathers. But these names are probably unfamiliar to the majority of the people who were afterward acquainted with him ; the future naturalist almost always signed himself, and friends and strangers always spoke of him as, Frank Buckland.

Dr. Buckland is said to have expected his son's birth with as much impatience as Mr. Shandy awaited the arrival of Tristram. When the nurse told him that the child was a boy, he declared that he should go at once and plant a birch, for he was determined that his son should be well brought up. The declaration proved a prophecy. Young Buckland was educated by his uncle, Dr. Buckland, of Laleham, the friend and kinsman of Dr. Arnold, but a most severe and even brutal pedagogue. He was subsequently sent to Winchester, and in due course passed on to Christchurch. At school he certainly received his share of chastisement, and within a year or two of his death he showed some of his friends scars on his hand which he said were his uncle's doing. He was probably a trying pupil to an impatient schoolmaster ; yet he contrived to acquire a large share of classical knowledge. He had whole passages of Virgil at his fingers' ends. He used to say, when he could not understand an act of Parliament,

that he always turned it into Latin; and within a fortnight of his death he was discussing a passage of a Greek play with one of the accomplished medical men who attended him, interesting himself about the different pronunciation of ancient and modern Greek and the merits of Greek accentuation. Mathematics were not supposed to form a necessary part of a boy's education forty years ago, and it may be doubted whether even his dread of his uncle's ferule or the discipline at Winchester could have induced him to make any progress in the study. To the end of his life he always regarded it as a providential circumstance that nature had given him eight fingers and two thumbs, as the arrangement had enabled him to count as far as ten. When he was engaged on long inspections, which involved the expenditure of a good deal of money, he always carried it in small paper parcels, each containing ten sovereigns; and, though he was fond of quoting the figures which his secretary prepared for him in his reports, those who knew him best doubted whether they expressed any clear meaning to him. He liked, for instance, to state the number of eggs which various kinds of fish produced, but he never rounded off the calculations which his secretary made to enable him to do so. The unit at the end of the sum was, in his eyes, of equal importance to the figure, which represented millions, at the beginning of it.

Of Mr. Buckland's Christchurch days many good stories are told. Almost every one has heard of the bear which he kept at his rooms, of its misdemeanors, and of its rustication. Less familiar, perhaps, is the story of his first journey by the Great Western. The dons, alarmed at the possible consequences of a railway to London, would not allow Brunel to bring the line nearer than Didcot. Dean Buckland in vain protested against the folly of this decision, and the line was kept out of harm's way at Didcot. But, the very day on which it was opened, Mr. Frank Buckland, with one or two other undergraduates, drove over to Didcot, traveled up to London, and returned in time to fulfill all the regulations of the university. The Dean, who was probably not altogether displeased at the joke, told the story to his friends who had prided themselves on keeping the line from Oxford. "Here," he said, "you have deprived us of the advantages of a railway, and my son has been up to London."

It was probably no easy task to select a profession for a young man who had already distinguished himself by an eccentric love for animals, which had induced him to keep a bear at Oxford and a vulture at the deanery at Westminster. At his father's wish, Mr. Buckland decided on entering the medical profession. To qualify himself for his duties, he studied in Germany, at Paris, and at St. George's Hospital. While he was at Paris the cholera was raging, and the patients who died of it in hospital were allotted to the Anatomical School. Mr. Buckland, however, had the stoutest of nerves and the strongest of constitutions, and never contracted any illness during the year of

sickness. He returned to London, and soon afterward became house-surgeon at St. George's. He used to say that the cases which were brought into the accident ward grouped themselves into classes according to the hours of the day. The suicides came at an early hour of the morning; the scaffold accidents next, since a scaffold, if it gave, way at all, gave way early in the day; the street accidents afterward, and so on. At St. George's he collected a fund of good stories, with which he used to amuse his friends to the last days of his life. One of the best of them told, as he never minded his stories telling, against himself. An old woman came to the hospital with a cough, which she declared nothing would alleviate except some sweet, luscious mixture which another out-patient, a friend of hers, had received. The old woman was given a bottleful of the mixture, and returned again and again for more, though her cough got little better. At last Mr. Buckland's suspicions were aroused, and he desired that his patient should be watched. She was watched, and was found outside Chelsea Hospital selling the mixture in halfpenny tarts.

In 1854, while he was still engaged at St. George's, he was offered and accepted the post of assistant-surgeon in the Second Life Guards. Perhaps no army surgeon ever enjoyed so much popularity among his brother-officers. The friends whom he made during his nine years with the regiment remained his friends to the day of his death; and, whenever any of them happened to meet him, Mr. Buckland had an endless store of anecdotes of his old Life Guards days. The nine years during which he served with the regiment were probably the happiest of his life. He left it on the surgeoncy falling vacant, and on finding that the rules of the service necessitated his own supercession by the transfer from another regiment of another surgeon. But during the nine years through which he had served his name had become famous. His contributions to the "Field" newspaper and his "Curiosities of Natural History" had made natural history popular in thousands of households; and the exertions which he had already commenced in the cause of fish-culture had marked him as a man with an idea. Thus he left the army a known man, and during the next few years relied on his pen. Unfortunately, he was unable to continue contributing to the paper which he had been instrumental in originating. Differences arose between himself and the conductors of the "Field," and Mr. Buckland, separating himself from his fellow-laborers, founded "Land and Water." It is not too much to say that the latter periodical was indebted to his pen for its existence and reputation.

A new sphere was, in the mean while, preparing for Mr. Buckland's energies. In 1861 Parliament had sanctioned the appointment of two Inspectors of Fisheries for England and Wales. One of these gentlemen, Mr. Eden, retired in broken health in 1867, and Mr. Buckland was chosen as his successor. He had hardly been appointed when his colleague, Mr. Ffennell, died, and another gentleman had to be chosen

for the second inspectorship. The old traditions of the office were thus snapped at the period of Mr. Buckland's appointment, and the new inspectors, without the assistance of an experienced colleague, had to map out their own policy. This is not the place to describe the policy which they pursued, or the results which ensued from it. It is sufficient to say that no public officer ever threw himself so heartily into his work as Mr. Buckland. His zeal frequently led him into imprudences which would have told severely on a less robust constitution, and which, perhaps, had the effect of shortening his own life. He has been known to wade up to his neck in water, and change his clothes driving away from the river on the box of a fly. This was an exceptional case; but it was a common thing for him to sit for hours in wet boots. He rarely wore a great-coat; he never owned a railway-rug; he took a delight in cold, and frequently compared himself to a polar bear, which languished in the heat and revived in the frost. The pleasure which Mr. Buckland derived from cold accounted for many of his eccentricities. Even in winter he wore the smallest amount of clothing; in summer he discarded almost all clothing. The illustrated papers, which have published portraits of him at home, have given their readers a very inaccurate idea of his appearance at his house in Albany Street. Those were very rare occasions on which he wore a coat at home. His usual dress was a pair of trousers and a flannel shirt; he deferred putting on socks and boots till he was starting for his office. Even on inspections he generally appeared at breakfast in the same attire, and on one occasion he left a large country-house, in which he was staying, with no other garments on. While he was driving in a dog-cart to the station he put on his boots, and as the train was drawing up to the station, at which a deputation of country gentlemen was awaiting him, he said with a sigh that he must begin to dress. Boots were in fact his special aversion. He lost no opportunity of kicking them off his feet. On one occasion, traveling alone in a railway-carriage, he fell asleep with his feet resting on the window-sill. As usual, he kicked off his boots, and they fell outside the carriage on the line. When he reached his destination the boots could not, of course, be found, and he had to go without them to his hotel. The next morning a plate-layer, examining the permanent way, came upon the boots, and reported to the traffic-manager that he had found a pair of gentleman's boots, but that he could not find the gentleman. Some one connected with the railway recollected that Mr. Buckland had been seen in the neighborhood, and, knowing his eccentricities, inferred that the boots must belong to him. They were accordingly sent to the Home Office, and were at once claimed.

We have said that he rarely wore a great-coat, and when he did so it was apparently more for the value of the additional pockets it contained than for its warmth. One of his good stories turned on this. He had been in France, and was returning, *via* Southampton, with an

overcoat stuffed with natural-history specimens of all sorts, dead and alive. Among them was a monkey, which was domiciled in a large inside breast-pocket. As Buckland was taking his ticket, Jocko thrust up his head and attracted the attention of the booking-clerk, who immediately (and very properly) said, "You must take a ticket for that dog, if it's going with you." "Dog?" said Buckland; "it's no dog; it's a monkey." "It is a dog," replied the clerk. "It's a monkey," retorted Buckland, and proceeded to show the whole animal, but without convincing the clerk, who insisted on five shillings for the dog-ticket to London. Nettled at this, Buckland plunged his hand into another pocket and produced a tortoise, and, laying it on the sill of the ticket-window, said, "Perhaps you'll call that a dog, too." The clerk inspected the tortoise. "No," said he, "we make no charge for them—they're insects."

If a close observer were asked to mention the chief quality which Mr. Buckland developed as Inspector of Fisheries, he would probably reply, a capacity for managing men. He had the happiest way of conciliating opposition, and of carrying an even hostile audience with him. It frequently occurred that the fishermen, at the many inquiries which his colleague and he held, looked in the first instance with suspicion on the inspectors. They never looked with suspicion on them when they went away. The ice of reserve was thawed by the warmth of Mr. Buckland's genial manner; and the men who, for the first half-hour, shrank from imparting information, in the next three hours vied with one another in contributing it. Mr. Buckland was equally at ease with more educated audiences, though in their case he was perhaps less uniformly successful. If he had been a politician, he would have been a greater mob orator than Parliamentary debater. But the higher classes, like the lower classes, could not resist the warmth of his manner or the ring of his laughter. He could not, in the most serious conversation, refrain from his joke; and some persons will recollect how on one occasion he was descanting, at a formal meeting, on the advantages which would ensue from the formation of a fishery district: "You will be appointed a conservator, and then you will impose license duties, and the money—probably three hundred pounds—will be paid to you." "And what shall I do then?" "Why, then," replied Mr. Buckland, "you had better bolt with it."

His love of a joke distinguished him as a lecturer. He remembered his father's lectures, and always thought it his first duty to make his audience laugh; and he had a dozen stories ready to provoke laughter. The excuse of a milk-boy, on a fish being found in the milk—"Please, sir, mother forgot to strain the water"—was one of those which did frequent duty. The same love of a joke followed him on his official inquiries. He left on one occasion a parcel of stinking fish, which he had carried about with him, and forgotten, neatly done up in paper, in a fashionable thoroughfare in Scotland, and stood at the hotel-window

to watch the face of the first person who examined it. He amused himself, one Sunday evening, on another occasion, in making herring-roe out of tapioca-pudding and whisky, to puzzle the witnesses whom he was to examine on the Monday; and he raised a laugh on a third occasion by telling a witness, who said he was a shoemaker, that, to judge from the appearance of the children's feet, he should think he had a very poor trade. Throughout his journeys, specimens of every kind, living, dying, and dead, were thrown into his bag, possibly to keep company with his boots or his clothes. The odor of the bag usually increased with the length of the inspection, and on one occasion, when it was exceptionally offensive, he said to the boots of a very smart hotel, "I think you had better put this bag into the cellar, as I should not be at all surprised if it smelt by to-morrow morning."

The love of fun and laughter, which was perceptible while he was transacting the dullest business, distinguished him equally as a writer. It was his object, so he himself thought, to make natural history practical; but it was his real mission to make natural history and fish-culture popular. He popularized everything that he touched; he hated the scientific terms which other naturalists employed, and invariably used the simplest language for describing his meaning. His writings were unequal: some of them are not marked by any exceptional qualities. But others of them, such as the best parts of the "Curiosities of Natural History," and "The Royal Academy without a Catalogue," are admirable examples of good English, keen critical observation, and rich humor. His best things, he used to say himself, were written on the box of an omnibus or in a railway-carriage. "The Royal Academy without a Catalogue" was written between London and Crewe, and posted at the latter station. He had originally acquired the art of writing in a railway-train from the late Bishop of Oxford. He practiced it with as much zeal as the Bishop did, and with as good effect. The more labored compositions which Mr. Buckland undertook did not always contain equal traits of happy humor. He was at his best when he took the least pains, and a collection of his very best pieces would deserve a permanent place in any collection of English essays.

Desultory work of this character made Mr. Buckland's name a household word throughout the country. His articles were copied and recopied into various newspapers, and obtained, in this way, hundreds of thousands of readers. But, at the same time, this desultory work necessarily prevented him from accomplishing any literary task of first-rate excellence. Some of his personal popularity was thus purchased at the cost of his future reputation; and a mass of knowledge has died with him which might otherwise have been preserved. It is no exaggeration to say that he had collected during his busy life a vast store of information. He had trained himself to observe, and his

eye rarely missed anything. He thought that he had facts at his disposal which would have enabled him to answer the great doctrines which Mr. Darwin has unfolded. Evolution was eminently distasteful to him; only two days before his death, in revising the preface of his latest work, he deliberately expressed his disbelief in it, and he used to dispose of any controversy on the subject by saying: "My father was Dean of Westminster. I was brought up in the principles of Church and state; and I will never admit it—I will never admit it."

Though, however, on such occasions as these Mr. Buckland used the language of advanced Tories, he habitually shrank from political discussion. He declared that he did not understand politics, and that he reserved himself for his own immediate pursuits. Into these pursuits he threw himself with his whole energy; and his energy was extraordinary. The greatest example of it was in the search which he made for John Hunter's coffin in the vaults of St. Martin's church. He literally turned over every coffin in the church before he found the one of which he was in search, spending a whole fortnight among the dead. He was ultimately rewarded by obtaining a grave for his hero's remains in Westminster Abbey. John Hunter was his typical hero. He had pursued the studies to which Mr. Buckland also devoted himself. He had founded a great museum. He had almost originated a science. Like John Hunter, one of Mr. Buckland's main objects was to form a collection which would illustrate the whole science of fish-culture. The museum at South Kensington, which he has left to the nation, exists as a proof of his success. Inferior, of course, to the similar collections in the Smithsonian Museum of the United States, it forms an unequaled example of what one man may accomplish by energy and industry. Thousands of persons have interested themselves in fish-culture from seeing the museum; and the collection has long formed one of the most popular departments of the galleries at South Kensington.

Energy was only one of Mr. Buckland's characteristics. His kindliness was another. Perhaps no man ever lived with a kinder heart. It may be doubted whether he ever willingly said a hard word or did a hard action. He used to say of one gentleman, by whom he thought he had been aggrieved, that he had forgiven him seventy times seven already; so that he was not required to forgive him any more. He could not resist a cry of distress, particularly if it came from a woman. Women, he used to say, are such doe-like, timid things, that he could not bear to see them unhappy. One night, walking from his office, he found a poor servant-girl crying in the street. She had been turned out of her place that morning as unequal to her duties; she had no money, and no friends nearer than Taunton, where her parents lived. Mr. Buckland took her to an eating-house, gave her a dinner, drove her to Paddington, paid for her ticket, and left her in charge of

the guard of the train. His nature was so simple and generous that he did not even then seem to realize that he had done an exceptionally kind action.

A volume might perhaps be filled with an account of Mr. Buckland's eccentricities. When he was studying oysters, he would never allow any one to speak ; the oysters, he said, overheard the conversation, and shut up their shells. More inanimate objects than oysters were endowed by him with sense. He had almost persuaded himself that inanimate things could be spiteful ; and he used to say that he would write a book on their spitefulness. If a railway-lamp did not burn properly, he would declare it was sulky, and throw it out of window to see if it could find a better master. He punished his portmanteau on one occasion by knocking it down, and the portmanteau naturally revenged itself by breaking all the bottles of specimens which it contained, and emptying their contents on its master's shirts. To provide himself against possible disasters, he used to carry with him an armory of implements. On the herring inquiry he went to Scotland with six boxes of cigars, four dozen pencils, five knives, and three thermometers. On his return, three weeks afterward, he produced one solitary pencil, the remnant of all this property. The knives were lost, the cigars were smoked ; one thermometer had lost its temper, and been thrown out of window ; another had been drowned in the Pentland Frith, and a third had beaten out its own brains against the bottom of a gunboat. No human being could have told the fate of the pencils.

Such were some of the eccentricities of a man who will, it may be hoped, be recollected by the public for the work which he did, and by his friends for his kindliness, his humor, and his worth. As he lived, so he died. Throughout a long and painful illness his spirits never failed, and his love of fun never ceased. "I wish to be present at this operation," was his quaint reply to the proposal of his surgeon that he should take chloroform, and his wonderful vitality enabled him to survive for months under sufferings which would have crushed other men. He is gone : his work is of the past ; and posterity will coldly examine its merits. But his friends will not patiently wait the verdict of posterity. When they recollect his rare powers of observation, his capacity of expressing his ideas, his quaint humor, his kindly heart, and open hand, they will say with the writer, we shall not soon look on his like again.—*Macmillan's Magazine.*

THE FELICITY OF NATURALISTS.

THERE is something very charming, especially to sedentary persons, in a sketch such as that of Mr. Frank Buckland, which has just appeared in "Macmillan," from the pen of Mr. Spencer Walpole. It is not that the sketch is at all particularly good as literature ; it is as good as it needed to be, but we read a hundred papers as good every year. Nor is it that Mr. Buckland's career was in any way suggestive of any tranquil or attractive sort of idyl. He was a man of business and a man of bustle, knew how to hurry, and from a curious kind of carelessness was very often in the state known as flurry. He could not keep anything he wanted, unless it were alive, and when over-bothered by human stupidity, such as that of the railway officials, who taxed a monkey as a dog and exempted a tortoise as a "hinsect," he could get very hot indeed. He lived a more or less commonplace though very active and useful life, working very hard as Fishery Commissioner, and chief contributor to "Land and Water," and correspondent-general to the practical naturalists of the United Kingdom, making the money he wanted, spending it as he liked, with a good deal of waste of silver, and generally demeaning himself as a valuable and bustling member of the community. He was not of the lotos-eaters, but of the breezy-bodies. The charm lies in the sense which the narrative evokes, that a very happy career, a life in which depression, and low spirits, and trouble generally are unknown, is quite possible to men. We have noticed that specialty in the lives of naturalists very often before, and begin to believe that it is to a quite separate degree peculiar to them. It is not unlikely that it should be so, for many of the great conditions of happiness are present in their lives. It is essential to true happiness to have some pursuit which strongly interests you ; and the naturalist has his pursuit, which never tires him, never fails him, and can never come to an end. The author requires subjects and leisure, the painter models, the student books and reasons for study ; but the naturalist is always ready, always engaged, always getting his result, even if it be a negative one, and never has the smallest prospect of getting to the end of his occupation. No matter how small may be the subdivision of the natural kingdom to which he attends, it is more extensive than his life will be. Not only does no man know all there is to be known about ants, or spiders, or minnows, but no man hopes to know, except by study of the knowledge of other men also, accumulated through ages. Most men get satiated or "weary," as they put it, of their businesses ; but who ever heard of a true naturalist retiring? The longest life, the hardest voyages, the most endless collections, will not satiate the curiosity of a conchologist about the colors, let alone the convolutions and the texture of his brilliant favorites.

No forester knows or will know all the trees of the forest, or, if he does, will know enough of their growth, structure, and climatic conditions of reproduction to be satisfied with himself. No ornithologist ever boasts even to himself that his knowledge of his kingdom, with its wonderfully separate subjects, so unlike all other living things in the grand condition of their lives, is more than fragmentary, or insusceptible of increase. He has never examined all the eagles' eyes, or the angles at which the humming-bird's feathers lie, and therefore flash so unaccountably. Who knows all about lions, or can prove whether or no the wild beasts' rage is an evolution from hereditary hunger continued through ages? Mr. Buckland attended to fish principally, fish from sharks to minnows, and collected, it is said, five thousand specimens, and was always hurrying about inspecting, or receiving, or writing about, new fishes; but, if he had lived a thousand years, he would not have exhausted his pursuit. There would have been still much to know about varieties of gills, and fins, and scales, and more about the fish which could or could not be cultivated; and when that had been done there would remain the inexhaustible and bewildering subject of the comparative intellectual capacity of different fishes. Do carp know their friends or not? A pursuit always so fresh, always so inexhaustible, and always so full of results, is one high condition of happiness; and it has occasionally, and might have oftener this addition—that the naturalist may live by it. Happy the man who in earning his living is in his groove of work, who feels that his faculties are not twisted or repressed by his daily labor, and has in his hardest toil pleasure; but what is his happiness to the naturalist's who earns his income in his play? Imagine the street-boy to whom hopscotch brings a reputable and sufficient subsistence, and yet who can never be tired of hopscotch! Mr. Buckland, curious in fish, and fond of open air, and of traveling about, and of fidgeting in briny places, was set to inspect fisheries, and instruct fishermen, and write about fish in "Land and Water," and tell mankind generally anything it might want to know about fishes, and all the while was adding to his own store and the world's store of knowledge of a subject which he justly thought great, and got by doing all that an excellent income. What wonder that he was happy and cheerful, and given to jocularities, sometimes very clever, sometimes only whimsical, occasionally a little foolish; and had in him a most attractive element of childlikeness, which even secluded fishermen, jealous of the "Government chaps," and half dreading either interference or fines, found it impossible to resist? They "cottoned" to him always, like dogs to a fearless child. Mr. Buckland could have induced Irish fishermen to fish without bounties, a feat supposed impossible; and the magnet in him was the naturalist's magnet, Audubon's, or White's, or Waterton's magnet, the charm of a nature full of the content which springs from harmony between interest and occupation. The man is fortunate who lives in the open

air and amid natural beauties, but the naturalist is never out of them; he is lucky who adds aught to the knowledge of his fellow-man, but the naturalist can not stir without making an addition to it; he is most favored whose occupation forces him to think of greater things than itself, who, like the astronomer, must, in order to learn, for ever look upward—and where is the naturalist without ever-present piety of some kind? It is very comic to hear that Mr. Buckland rejected evolution, because "my father was Dean of Westminster; I was bred in the principles of Church and state, and I will never admit it"; but the thought which prompted that half-humorous, half-serious expression of his faith was not comic at all. He could not, as naturalist, stand a theory which struck him (quite erroneously) as dispensing with, or even affronting, a sentient First Cause. The child in him —which in Mr. Buckland, as in every man who loves Nature with a single heart, was very strong—revolted, and grew pettish.

There is something, however, in the naturalist's pursuit besides happiness which gives him his tribal qualities, those always found with his pursuit, and it is a little difficult to decide quite satisfactorily what it is. It is not the pursuit of knowledge in itself. Scholars and metaphysicians, and men of the sciences which relate to other things than outdoor nature, physicians, for instance, and electricians, are not like the naturalists at all. Indeed, we do not quite know why the pursuit of knowledge of itself should tend to good any more than any other indulgence of curiosity. Nor is it all the open air, for the men who next to the naturalists live most in that, agricultural peasants, belong to a far removed type of men. Nor is it a certain innocence and permanent absence of sinister temptation which attaches to the pursuit, for many pursuits—antiquarianism, for instance—are quite as innocent yet evolve a totally different order of mind, a mind often very much more reflective and less simple. Naturalists, too, are of necessity incessantly killing, and constant though innocent killing seems, as in butchers, rather to brutalize than to refine the general character. Butchers' boys are not breezy people at all, nor, for that matter, are fishmongers or poulterers. The goodness of naturalists, like the serenity of Arctic voyagers, is of a kind *per se*, a quality which we scarcely discover in any other class, a benevolence quite unfailing and almost Christlike in persons otherwise very human indeed.

May it not be that the instinct of mankind is true—that Nature, an undeteriorated work of God, has in it something better than man, and in close contact with the mind gives that something out? It may be said that we do not find this result in the savage, even if he be Hawaian or Guacho—that is, even if he lives always amid scenes of unfailing beauty; but that is because the savage's mind is closed to the necessary contact. But we do find it in the sportsman, who, even if in other ways objectionable, or even brutalized by the constant and objectless slaughter of things more beautiful than himself, has often in

him something of that which we find in a higher degree in naturalists, and which comes to all who can receive it from contact with Nature face to face. Very dreamy, all that! Very true; but, if we never dream, there are large regions of thought of which we shall understand nothing, for in them only hypothesis and sympathy can possibly be our guides.—*Spectator.*

PLANTATION FOLK-LORE.*

By Professor T. F. CRANE.

IN a passage in his recent essay on Hawthorne, which was received with some disfavor by his countrymen, Mr. James enumerated the "items of high civilization which are absent from the texture of American life." To these might be added an item of low civilization, but what, for the purpose of the imaginative writer, is of greater utility than the court or Epsom—folk-lore. With the exception of a few legends of the Hudson due to the Dutch, and an occasional Indian legend (generally manufactured by the white man), there are no local legends from one end of the land to the other. In minor matters, such as superstitions, the case is no better; aside from the aversion to Friday, and sitting thirteen at table, we know of no general superstition. There are, however, two classes of native Americans which must be exempted from the application of the above rule—the Indians and the Southern negroes. The superstitions of the latter, chiefly religious, have been darkly hinted at from time to time, and have occasionally afforded slight contributions to fiction; a few, the reader will remember, are to be found in Mark Twain's amusing book, "Tom Sawyer."

It was not suspected that the negroes possessed a large fund of one of the most entertaining classes of popular tales—animal stories—until a number were published in the "Riverside Magazine" (November, 1868; March, 1869), "taken down from the lips of an old negro in the vicinity of Charleston," variants of which appeared in the New York "Independent" (September 2, 1875), and from time to time in other papers. The first attempt at anything like a full or complete collection of these tales is in the book before us, which is not only a most entertaining and novel work but a valuable contribution to comparative folk-lore. The volume is divided into "Legends of the Old Plantation" and "Uncle Remus's Songs and Sayings." In addition to these there are some proverbs and "A Story of the War." The true value of the book, however, is in the thirty-four inimitable "Legends of the Old Plantation," which are related night after night by an old negro to the little

* Uncle Remus. His Songs and his Sayings. The Folk-Lore of the Old Plantation. By Joel Chandler Harris. New York: D. Appleton & Co., 1881.

grandson of his former owner. Too much praise can not be bestowed upon Mr. Harris for the manner in which he has executed his task: not only is the representation of the dialect better than anything that has heretofore been given, but he has shown himself a master in the difficult art of collecting popular tales. A glance at the variants of these stories published elsewhere will show the vast superiority of Mr. Harris's. It is not, however, in their literary character, interesting as it is, that we intend to examine briefly these fables, but simply in their relations to the similar tales of other countries.

Mr. Harris does not state the precise locality where he collected his fables. To cite the words of a competent critic ("The Nation," December 2, 1880): "Presumably his stories are all of Georgian origin, though he cites a variant from Florida; and he gives us proof that 'they have become a part of the domestic history of every Southern family.' However widely they may have been spread through our domestic slave-trade, we regard it as highly probable that the Sea-Island neighborhood from South Carolina to Florida was, as in the case of the slave-songs, the focus of the animal fables—an hypothesis which finds its support in the reference of both to an African and heathen origin." We have at present but scanty information as to the extent of the diffusion of these stories—variants have been found in South Carolina and Florida; no locality is mentioned for those given in the interesting article on "Folk-Lore of the Southern Negroes," by William Owens, in "Lippincott's Magazine," December, 1877, pp. 748–755.*

These stories narrate the contests of wit between the rabbit, the terrapin, the bear, the wolf, and the fox. The first two, who are the embodiments of weakness and harmlessness, are always victorious; as Mr. Harris says, "It is not virtue that triumphs, but helplessness; it is not malice, but mischievousness." The animals are all dignified with the title *Brer*, or *Buh*, as represented by Mr. Owens, who says, "It is generally supposed to be an abbreviation of the word 'brother'" (the *br* being sounded without the whir of the *r*), "but it probably is a title of respect equivalent to our Mr." The manners and customs of human beings are, after the usual fashion of fables, transferred to the animals in a way that excites the wonder of Uncle Remus's youthful auditor, and a mysterious Miss Meadows and "de gals" are introduced, with whom the animals are on terms of intimacy, and at whose house some of the most amusing incidents take place. A glance at the contents of these fables will at once reveal many familiar episodes, a few of which we shall note for a specific purpose.

In No. XVI, "Old Mr. Rabbit he's a Good Fisherman," Brer Rab-

* There are four stories in this article which have no parallels in "Uncle Remus": "Buh Rabbit, Buh Wolf, and the Pears"; "Buh Rabbit frightens Buh Wolf"; "The Rooster and the Cornbread;" and "Buh Elephant and Buh Lion," which last has a distant resemblance to a story in Koelle's "African Native Literature," London, 1854, p. 177.

bit, while the Fox, Coon, and Bear are clearing up "a new groun' fer ter plant a roas'n' year patch," slips away and hunts for a cool place to rest in. He finally came across a well with a bucket hanging in it and looking so cool that Brer Rabbit climbed in, and of course the bucket began to descend; "but Brer Rabbit he keep mighty still, kaze he dunner w'at minnit gwineter be de nex'. He des lay dar en shuck en shiver." The Fox saw the Rabbit slip away and followed him, and his amazement can be imagined when he saw the Rabbit disappear down the well. The Rabbit on being asked, "Who you wizzitin' down dar?" answered that he was fishing, and invited the Fox to get into the other bucket and come down and help him. This the Fox did, and as he went down up went Brer Rabbit. The Fox is afterward pulled up by the owner of the well and escapes. This fable will be recognized at once from the familiar version in La Fontaine (XI, 6, "Le Loup et le Renard"), which he took from the "Roman de Renart." A much older version is found in the "Disciplina Clericalis," a collection of Oriental stories made in the first years of the twelfth century.

No. XVII, "Mr. Rabbit nibbles up the Butter," relates how Brer Rabbit, Brer Fox, and Brer Possum laid up their provisions together in the same shanty, and put the butter that Brer Fox brought into the spring-house to keep it cool. Brer Rabbit, however, under the pretense of going to see his family, leaves his companions at their work and takes a nibble at the butter. This goes on until the butter disappears, and, while the others are sleeping, Brer Rabbit smears Brer Possum's mouth with the butter on his paws. Brer Possum on waking up was naturally indignant, and demanded an ordeal by fire to prove his innocence, but, as ordeals among men even must sometimes have failed, the innocent Possum is burned up, greatly to the indignation of Uncle Remus's listener. With this story may be compared Grimm, No. 2, "The Cat and the Mouse in Partnership." A closer parallel is found in W. H. I. Bleek's "Reynard the Fox in South Africa; or Hottentot Fables and Tales" (London, Trübner, 1864, p. 18), "Which was the Thief?"

"A Jackal and a Hyena went and hired themselves to a man to be his servants. In the middle of the night the Jackal rose and smeared the Hyena's tail with some fat, and then ate all the rest of it which was in the house. In the morning the man missed his fat, and he immediately accused the Jackal of having eaten it. 'Look at the Hyena's tail,' said the rogue, 'and you will see who is the thief.' The man did so, and then thrashed the Hyena till she was nearly dead."

In No. XXV, "How Mr. Rabbit lost his Fine Bushy Tail," the Rabbit is victimized by the Fox, who persuades him to fish, one cold night, by dropping his long, bushy tail (rabbits formerly had such) into the water. It freezes fast, of course, and the poor Rabbit to get away is obliged to leave his tail in the ice. This is one of the familiar episodes in the "Roman de Renart."

Some of the stories contain incidents which are common to European popular tales, as in No. XX, "How Mr. Rabbit saved his Meat." Brer Wolf suspected Brer Rabbit of stealing some of his fish, and killed Brer Rabbit's best cow. The latter frightened the Wolf away by telling him that the "patter-rollers" (patrol, policemen) were coming, and proceeded to skin the cow and salt down the hide and stow away the carcass in the smoke-house. The end of the cow's tail he stuck in the ground, and called Brer Wolf. "Run yer, Brer Wolf, run yer! Yo' cow gwine in de groun'!" When Brer Wolf arrived, he found Brer Rabbit holding the tail with all his might to keep the cow from going into the ground. Brer Wolf caught hold, and off came the tail. The Wolf was not going to give the matter up so, and got a spade, a pick-axe, and a shovel, and began to dig for his cow, while Brer Rabbit sat on his front-porch smoking his cigar and watching him. This episode is found in a Basque story (Webster's "Basque Legends," p. 10) and in an Italian tale ("Jahrbuch für roman. und eng. Lit.," VIII, 252), and in many others that we have not space to mention.

No. XIII, "The Awful Fate of Mr. Wolf," relates how the Wolf persecuted Brer Rabbit, and carried off some of his family. To protect those left, "Brer Rabbit b'ilt 'im a straw house, en hit wuz tored down; den he made a house outen pine-tops, en dat went de same way; den he made 'im a bark house, en dat wuz raided on; en eve'y time he los' a house, he los' wunner his chilluns." Finally, he built a plank house with rock foundations, and then could live in peace. One day the Wolf, pursued by dogs, took refuge in Brer Rabbit's house, and begged him to hide him from the dogs. The Rabbit told him to get into a chest, and, the Wolf once secure, the Rabbit bored holes in the top of the chest, and poured boiling water in and scalded the Wolf to death. A similar story, except that seven Pigs and a Fox take the place of the Rabbits and Wolf, is told by Mr. Owens ("Lippincott," December, 1877, page 753), who cites as a parallel the Anglo-Saxon story of "The Three Blue Pigs." Another parallel may be found in a Venetian story (Bernoni, "Tradizioni Popolari Veneziane," p. 69, "El Galo").

One of the incidents in No. XX, "A Story about the Little Rabbits," is also familiar, and seems like a curious metamorphosis of a well-known trait of fairy tales. The Fox goes to Brer Rabbit's house, and the sight of the fat little Rabbits makes his mouth water, and he endeavors to invent some excuse for killing them. He finally sets them difficult tasks to do, intending to devour them if they fail; but a little Bird on top of the house sings the solution of all the difficulties, which are: to break off a piece of sugar-cane; to bring water in a sieve; and to put a big log on the fire. The second task is the one found in European folk-lore, an example occurring in another Venetian story (Bastanielo, Bernoni, "Fiabe," No. 6).

One of the most amusing stories in "Uncle Remus" is No. II, "The Wonderful Tar-Baby Story" (versions also in "Riverside Magazine," 1868, p. 505, and "Lippincott," December, 1877, p. 750), in which the Fox made "a contrapshun wat he call a Tar-Baby," out of tar and turpentine, and put it in the way of the Rabbit, who got stuck to it, and thus fell into the Fox's clutches. In the "South-African Folk-Lore Journal," I, p. 69, there is a curious parallel to the above story. A number of animals build a dam to hold water, and the jackal comes and muddies the water. A baboon is set to guard the dam, but the jackal easily outwits him. Then the tortoise offers to capture the jackal and proposes "that a thick coating of 'bijenwerk' (a kind of sticky, black substance found on beehives) should be spread all over him, and that he should go and stand at the entrance of the dam, on the water-level, so that the jackal might tread on him, and stick fast." The jackal is caught, but, with his customary craft, escapes.

In the last of Uncle Remus's stories, No. XXXIV, "The Sad Fate of Mr. Fox," the Fox and the Rabbit jump down the mouth of a cow and help themselves to meat, the Fox warning the Rabbit not "to cut 'roun' de haslett." The Rabbit disobeys the injunction, and the cow falls dead. The owner cuts her open to see what was the matter, and the Rabbit betrays the Fox, who was hiding in the "maul," and who is thereupon killed. In Bleek, p. 27, the Elephant and the Tortoise have a dispute, and the former determined to kill the latter, and asked him, "Little Tortoise, shall I chew you or swallow you down?" The little Tortoise said, "Swallow me, if you please!" and the Elephant swallowed it whole. After the Elephant had swallowed the little Tortoise, and it had entered his body, it tore off his liver, heart, and kidneys. The Elephant said, "Little Tortoise, you kill me." So the Elephant died; but the little Tortoise came out of his dead body and went wherever it liked.*

More remarkable, however, than the above casual points of resemblance is the substantial identity of these stories with those of a tribe of South American Indians. In 1870 Professor C. F. Hartt heard, at Santarem on the Amazons, from his guide in the *lingua geral*, a story, "The Tortoise that outran the Deer," a version of which he afterward published in the "Cornell Era" (January 20, 1871), and which attracted the attention of a writer in "The Nation" (February 23, 1871), who gave a variant of the same myth, as found among the negroes of South Carolina (the same story occurring in "Uncle Remus," p. 80).

* Mr. Harris includes among the animal fables a story which properly does not belong there, and which is nothing but a well-known European tale which Uncle Remus must have heard from the whites, although Mr. Harris, p. 136, note, says, "This story is popular on the coast and among the rice-plantations, and, since the publication of some of the animal-myths in the newspapers, I have received a version of it from a planter in southwest Georgia." The story in question is No. XXXII, "Jacky-my-Lantern," and is nothing but a version of the French story of "Bonhomme Misère," which is of Italian origin. (See Pitrè, "Fiabe," Nos. 124, 125; De Gubernatis, "Novelline di Sto. Stefano," No. 32, etc.)

This singular resemblance does not seem to have been noticed again until Mr. Herbert Smith, in his "Brazil, the Amazons, and the Coast" (New York, Charles Scribner's Sons, 1879), in a chapter devoted to "The Myths of the Amazonian Indians," gave a number of animal fables, but, owing to his insufficient acquaintance with comparative folk-lore, he was unable to throw any light on the subject, merely noticing the resemblances which had already attracted the attention of Professor Hartt and others. The proof-sheets of this chapter were sent to Mr. Harris, who at once saw that the similarity extended to almost every story quoted by Mr. Smith, and some are so nearly identical as to point unmistakably to a common origin; but when and where? Mr. Harris asks, "When did the negro or the North American Indian come into contact with the tribes of South America?"

Before examining this question, it may be well to compare hastily the stories in Hartt's "Amazonian Tortoise Myths" (Rio de Janeiro, 1875) and Smith's "Brazil" with their parallels in "Uncle Remus" and elsewhere. First, let us examine the stories common to Hartt, Smith, and Uncle Remus:

I. "How the Tortoise outran the Deer" (Hartt, p. 7; Smith, p. 543, gives the version in Hartt, saying: "I quote Professor Hartt's words for this story, as being better than the version, substantially the same, that I find in my note-book. The story is very common all over the Amazons."—"Riverside Magazine," November, 1868, p. 507; "Cornell Era," January 20, 1871; "Nation," February 23, 1871, p. 127; and "Lippincott's Magazine," December, 1877, p. 751). The Tortoise declares that it can outrun the Deer, and the latter challenges it to a race. The Tortoise secretly posts members of its family along the course, who answer for him when the Deer asks if he is ahead. The race begins, and the Deer is so bewildered at hearing the Tortoise's voice always ahead of him, that he runs against a tree and falls down dead. In "Uncle Remus" the Rabbit takes the place of the Deer, and the story ends with the Terrapin's victory without the death of his rival. In "Lippincott" the actors are Buh Rabbit and Buh Frog; but the writer remarks that another version makes the competitors Buh Deer and Buh Cooter (the Negro name for terrapin, or land-tortoise). A German version of this story is given in the "Riverside Magazine," September, 1868, and a version from Siam may be found in the "Orient und Occident," III, 497. A more important and significant parallel, however, is to be found in Bleek, No. 16, p. 32, "The Tortoises hunting the Ostriches": "One day, it is said, the Tortoises held a council how they might hunt Ostriches, and they said: 'Let us, on both sides, stand in rows near each other, and let one go to hunt the Ostriches, so that they must flee along through the midst of us.' They did so, and, as they were many, the Ostriches were obliged to run along through the midst of them. During this they did not move, but, remaining always in the same places, called each to the

other, 'Are you there?' and each one answered, 'I am here.' The Ostriches, hearing this, ran so tremendously that they quite exhausted their strength, and fell down. Then the Tortoises assembled at the place where the Ostriches had fallen, and devoured them."

II. "How the Tortoise provoked a Contest of Strength between the Tapir and the Whale" (Hartt, p. 20; Smith, p. 545; "Uncle Remus," p. 111). In Hartt, a Tortoise went down to the sea to drink, and a Whale made sport of him, but the former said he was stronger than the latter, and could pull him on shore. The Whale laughed, but the Tortoise went into the forest to get a long root, and, while, looking for it, met a Tapir, who asked him what he was doing. The Tortoise replied that he was looking for a root to pull the Tapir into the sea with. The Tortoise found his root, and tied one end to the Tapir and the other end to the Whale (of course, both remaining in ignorance of the performance); the two then tugged against each other, and finally gave up the struggle from sheer exhaustion. In another version (p. 23) the *cobra grande*, or mythical great serpent, and the jaguar are made to pull against each other in the same way. Smith mentions a version he himself heard, and then gives Professor Hartt's. In "Uncle Remus" Brer Terrapin brags that he can out-pull Brer Bear, and, borrowing Miss Meadows's bed-cord, he gives one end to the Bear, and, diving down into the water, fastens his own end to a big root, and the Bear soon gives up pulling against Brer Terrapin.

III. In a version of another story, "How a Tortoise killed a Jaguar" (Hartt, p. 29; Smith, p. 542; "Uncle Remus," p. 60), the Jaguar is represented as reaching down into the burrow and catching hold of the Tortoise, who, resisting, calls out, "Oh, you foolish fellow! you think you have caught me, when it is only the root of a tree you have secured." In "Uncle Remus," the Fox, in revenge for what will be told in the following story, determines to kill Brer Terrapin. The latter begs piteously not to be drowned, and the Fox, taken in by this, souses him into the water, still holding on to him, when the Terrapin "begin fer ter holler, 'Tu'n loose dat stump, en ketch holt er me.' Brer Fox he holler back, 'I ain't got holt er no stump, en I is got holt er you.'" But at last he was deceived by the Terrapin's cry that he was drowning, and let go of him.

IV. In the last-mentioned story, "How a Tortoise killed a Jaguar" (Hartt, p. 26; Smith, p. 541; for one incident only, "Uncle Remus," p. 52), a Monkey carried a Tortoise up into a palm-tree to eat the fruit. When his hunger was satisfied, the Tortoise wished to descend, but the Monkey had gone, so the Tortoise had to remain there until a Jaguar came along and asked him why he didn't come down. The Tortoise said he was afraid, but the Jaguar said: "Don't be afraid! Jump! I will catch you!" Then the Tortoise jumped down and struck the Jaguar on the head and killed him. In Mr. Smith's version, collected at the same place (Santarem), the Tortoise, after throw-

ing the Jaguar down some fruit, slips off the tree, and, falling on the Jaguar's head, kills him. In "Uncle Remus," while the Rabbit and Terrapin are calling at Miss Meadows's, the Fox comes in on them unawares, and the Terrapin, who has been put up on a shelf, rolls off in his agitation, falls on the head of the Fox, and stuns him a moment, so that Brer Rabbit escapes.

These are all the stories in Hartt which have full or partial parallels in "Uncle Remus"; there are, however, several additional ones in Smith that belong here.

V. "Story of the Jaguar who wanted to marry the Deer's Daughter, but was cut out by the Cotia" (Smith, p. 547; "Riverside Magazine," 1868, p. 505; "Lippincott's," 1877, p. 753; and "Uncle Remus," p. 34). The Cotia brags that he can ride the Jaguar, and the Deer promises to give him his daughter if he does. The Cotia pretends to be ill, and the Jaguar charitably takes him on his back, and even ties him on with a root, and gives him a switch. When the Cotia finds himself master of the situation, he whips the Jaguar unmercifully, and rides him by the Deer's house. In "Lippincott" the Rabbit and Wolf, in the other versions the Rabbit and Fox, are the parties concerned.

VI. In the conclusion of Smith's version, p. 549, the Cotia slipped off the Jaguar's back, and hid in a hole before the latter could catch him. The Jaguar set an Owl to watch the hole, but the Cotia peeped out and threw a handful of sand in the Owl's face and ran away. A somewhat similar incident is found in "Uncle Remus," p. 39 ("Riverside Magazine," 1868, p. 506, III, at end), but, instead of throwing sand in the Buzzard's eyes, the Rabbit makes him believe that there is a squirrel in the tree in which the Rabbit is imprisoned, and, when the Buzzard rushes around to catch it, the Rabbit escapes.

VII. "Story of the Cotia who played Tricks on the Jaguar and outwitted him" (Smith, p. 549, at end). The Jaguar, enraged at the tricks played upon him by the Cotia, caught the latter and tied him to a tree, intending to drown him in the morning. The Cotia expressed his joy at this determination, and remarked that he would be very sad if he was going to be thrown into a brier-bush. The Jaguar, of course, changed his mind and threw his enemy into a brier-bush; whereat the Cotia ran away laughing. The same incident precisely occurs in "Uncle Remus," p. 29 ("Riverside Magazine," 1868, p. 505, I), with the Fox and the Rabbit, who begs, "fer de Lord's sake, don't fling me in dat brier-patch!" The Fox is again deceived, and the Rabbit, as he escapes unhurt, cries out, "Bred en bawn in a brier-patch, Brer Fox!"

VIII. A variant of the last story(Smith, pp. 552, 554) relates that, to be avenged on the Cotia, the Lion and Jaguar guarded a spring, so that the Cotia could get nothing to drink. After a time the Cotia became very thirsty, and, seeing a man pass with a jar on his head, said to himself, "I will see if I can get some water from

that jar." So he ran ahead of the man and lay down in the path. The man thought it was a dead Cotia, and shoved it aside with his foot and went on. This the Cotia repeated four times, and at last the man said: "Here's another dead Cotia! Now, I will go back and get the others, and carry all four home." He put down the jar and went to look for the other Cotias. Then the Cotia jumped up and thrust his head into the jar, which contained molasses instead of water. In "Uncle Remus," p. 70, the Rabbit, by a similar stratagem, steals Brer Fox's game. Mr. Smith, p. 558, note, mentions a parallel to this story from Egypt (Khunzinger, "Upper Egypt, its People and its Products," p. 401). I do not recall any parallel in which animals are the actors; but a similar trick is found in many versions of the story of "The Master Thief," for instance, in Asbjörnsen and Moe's "Norske Folke-Eventyr," No. 34, "Mestertyven."

We are prepared now to consider briefly the origin of these stories, which are substantially the same in Brazil and in the Southern States. That the negroes of the United States obtained these stories from the South American Indians is an hypothesis no one would think of maintaining; but that the Indians heard these stories from the African slaves in Brazil, and that the latter, as well as those who were formerly slaves in the United States, brought these stories with them from Africa is, we think, beyond a doubt, the explanation of the resemblances we have noted. Owing to a scarcity of materials, we have not been able to show very clearly the African origin of these stories, but what we have cited makes it at least probable. Whether the African stories of "Reynard the Fox" are original with the Hottentots, or have been communicated to them by the Dutch, is a point we can not decide, in the absence of more ample material for comparison.

The most interesting point in the present investigation, and one that connects it with the recent discussions on the subject of folk-lore, is that, if our explanation be true, it shows that popular tales are more readily diffused than has heretofore been supposed. Professor Hartt ("Amazonian Tortoise Myths," p. 5) says: "The question has arisen, whether many of the stories I have given, that bear so close a resemblance to Old World fables, may not have been introduced by the negroes? But I see no reason for entertaining this suspicion, for they are too widely spread, their form is too thoroughly Brazilian, they are most numerous in just those regions where negroes are not and have not been abundant, and, moreover, they occur, not in Portuguese but in the *lingua geral*." The first objection would simply show the extent of the diffusion, the second what would naturally take place on the introduction of stories from a country with a different fauna, and the final objections were overthrown, we believe, by Professor Hartt's hearing these same stories from the negroes in Rio. He gave up the hypothesis of an Indian origin, and did not continue his collection. Mr. Smith (p. 548) makes about the same objections, which are invali-

dated by the writer's own admissions: "They are repeated in remote provinces, among half-wild tribes who *hardly* (the italics are ours) ever see the negroes. . . . Many of the tortoise myths are told by the Mundurucú Indians, the *majority* of whom can not speak Portuguese." Mr. Smith also confirms, what has been said above, that these stories are told in Rio by the negroes, and a very suspicious circumstance is the introduction of a lion into one of the stories (p. 551), which, as Mr. Smith remarks, "shows that the narrator had heard of lions, probably from the slaves."

In taking leave of this interesting subject we must reiterate our praise of Mr. Harris's charming volume, and we trust that its scientific side may not be overlooked, but awaken an interest in negro folk-lore which will result in other works as entertaining and valuable as "Uncle Remus."

AN ANCIENT SCIENTIST.

READERS of Mrs. Browning will remember in the "Vision of Poets" the description of Lucretius, as one

> "Who dropped his plummet down the broad,
> Deep universe, and said, 'No God,'
>
> "Finding no bottom. He denied
> Divinely the Divine, and died
> Chief poet by the Tiber side."

In spite of this high encomium, approved by men of taste in all ages, the subject of this sketch is far less known to fame than many others of much smaller ability either as poets or as philosophers. He is unknown to many, to whom Virgil, Horace, Juvenal, and even Ovid, are household words. And yet, of these four, Virgil alone can contest the palm of supremacy with him. When Tyndall, in his famous Belfast Address, introduced his typical Lucretian as an opponent to Bishop Butler, many well-informed people were driven to their classical dictionaries to discover whom the orator meant.

It is not easy to say what are the causes of this neglect. Lucretius is not only one of the few first-class poets in Latin literature, but he is also one of the most subtile and original thinkers that Rome ever produced. His system shows how far scientific speculation had gone in his day, and what views the most enlightened took in regard to the structure of the universe and the problems of matter and life. His theories are plausible, and sometimes have anticipated modern hypotheses and discoveries. Yet few really know who he was and what his doctrines are. It is to supply this wanting knowledge—to show what

relation Lucretius actually bears to science—that this summary of his principles was written.

Titus Lucretius Carus was born 96 B. C., and was thus the contemporary of Cicero, Cæsar, and Sallust. As with many other great men, little of his personal life is known. It appears that in his youth he studied philosophy at Athens in company with Cicero and other Romans afterward distinguished in politics and literature. Beyond this we know nothing certain of his life. He died B. C. 52, while Horace was still a schoolboy at Rome and Virgil had just reached the age of manhood. There is a story that his wife, fearing a decrease in his affection toward her, had given him a love-philter, which made havoc with his brain, and filled his mind with base thoughts, so that sooner than endure them he killed himself. This version of his death is well known through Tennyson's poem "Lucretius"; it, however, is a matter of tradition, and not of history.

From his life we now turn to his great work, "The Nature of Things." In this he lays down the whole system of the Epicurean philosophy, a system which has been more vilified and misrepresented than any other put forth by man. Its physical basis was the atomic theory, which was first promulgated by Leucippus. The real founder of the school was Democritus of Abdera, to whom Bacon awards a high place among great thinkers. The great exponent of these doctrines was Epicurus, from whom the system takes its name. He lived mostly at Athens in the third and fourth centuries before Christ, and was noted for his frugal and virtuous life. His moral principles did not consist in reckless indulgence of the senses, but in moderation in all things, and in avoidance of pain, whether moral, mental, or physical. This principle is continually set forth and illustrated by Horace, especially in his "Satires." In him the tenets of the Epicurean philosophy become the maxims of a prudent, intelligent man of the world.

But it is with the scientific aspect of this system, as set forth by Lucretius, that we have chiefly to do. Its principles are contained in six books of twelve or thirteen hundred lines apiece. It is best to take up the books in their order, as the argument is closely connected throughout.

The first book contains the broad principles of the atomic theory. After a beautiful passage describing the benumbing power of superstition, he asserts that the only means of overcoming this is found in the study of nature, and declares that the difficulty of the task shall not prevent him from attempting it. The first principle which he lays down is, that all matter is uncreated; or, as he expresses it, nothing can spring from nothing. For, if anything can spring from nothing, what need is there of these long processes of birth and growth and these aids to development? Why should all this labor be spent in vain, if anything could become what it is without labor? This is simply

the ordinary scientific argument from experience, and, although not strictly logical, is an expression of the conviction, common to every student of Nature, of the continuity and permanence of physical law. This conviction is not supported by arguments, but is built up slowly and surely by the daily observation of Nature's working and of the never-failing fulfillment of her laws. Our author's reasoning, therefore, is calculated rather to convince the man of science than the mere logician.

Having established this principle, he goes on to state the converse, that matter is never annihilated. For, he argues, since nothing can be created, a continual unreplaced loss would have been going on, which in the infinite course of past time would have left nothing of the universe at all. Here, again, he shows that he has the scientific conviction of the uniformity of nature. An objector might have said, "Though there has been no loss, no annihilation in time past, how do you know that there will be none in time future?" This argument, though unanswerable, is incapable of producing conviction in a scientific mind. Such an argument, as Tyndall remarks in his "Fragments of Science," is employed by the spiritualists in regard to the sun's failing to rise on the morrow. "Before such a state of mind," says he, "the scientific intellect is absolutely powerless." The convictions that rise from uniform experience in the pursuit of physical studies are unassailable by any reasoning short of a mathematical demonstration.

Lucretius adds that, in many cases of apparent annihilation, matter is but lost to grow again in another form. He instances the rain whose drops fall upon the ground and are scattered, but appear again in the blooming tree which shelters beneath its branches flocks and herds and the race of men. Here, as often with this poet, a beautiful episode crops out in the midst of his philosophical argument. Indeed, it is one of his characteristics, and forms his claim to be considered a great poet, that, combined with his appreciation of the order and continuity of nature, he has a fervent love for all its aspects of beauty and life. Often he turns aside to tell of frisking lambs and babbling brooks, and trees that spread their branches far and wide. He seems to have loved nature in all its forms, and to have devoted to it all the wealth of his intellect and imagination. He closes this argument with the celebrated saying, "Nature builds up one thing by means of another, and suffers nothing to be born except another die."

These two propositions, that nothing is created and nothing destroyed, are the primary postulates upon which as a foundation he builds the whole theory of atoms. His first step is to show that there are bodies, which, though invisible, are yet appreciable through the senses. The air, he argues, must consist of solid particles in as true a sense as water, for water itself can not produce greater effects than violent winds. There are, too, other particles of matter which affect

the other senses, but not that of sight. This is proved by the sensations of sound, heat, and smell, which must be produced by matter, for to give rise to the feeling of touch is the essential property of matter and of matter alone. This property is what he calls an *officium corporis*—that is, a "function of substance"; another which he mentions afterward is weight, or the tendency to proceed downward. He also demonstrates the presence of aqueous vapor in the air by the phenomena of absorption and evaporation. A quotation of his language at this point will give a fair idea of his logic and his style: "In short, garments hung on the surf-beaten shore grow moist, but if spread out in the sun they become dry again. Yet we have not seen how the moisture of the water made its way in, nor how it vanished beneath the heat. The water, then, is scattered into minute parts, which the eyes can in no way behold." He employs arguments that are in use nowadays in physics to prove the smallness to which matter can be subdivided. The most solid bodies, such as rings upon the fingers and the very stones beneath our feet, are worn away by constant rubbing. "But," as he goes on to say, "the nature of sight has enviously shut off the view of those portions of the substance which disappear at any one time."

The arguments which he uses in this connection form an additional proof of the scientific tendency of Lucretius's mind. In his time the inductive and experimental methods were imperfectly understood and little practiced. He himself does not appear to have attained to them, he was bound by the false philosophical notions of the Greeks; yet often, as here, he traces the cause from various effects with considerable sagacity. He has in several cases, though generally on insufficient evidence, anticipated some of the results of modern research. It is easy to see how his opinions would have been strengthened, and what added breadth and vigor of reasoning he would have gained, if he had stood on our vantage-ground and had known all that we now know. As it is, we feel surprised at finding that he accomplished so much with such imperfect material for his work.

We do not intend to follow the entire development of his theory, but merely to trace his relations to science and the scientific spirit. The rest of the first book and the whole of the second are taken up with a description of the action and properties of the primitive atoms, of which he supposes all things to be composed. Amid some arguments that appear reasonable, he brings forward a striking fallacy. "If," says he, "matter is infinitely divisible, the greatest and the least, consisting equally of an infinite number of parts, must be equal." In other words, a mile and an inch are equal, for they each consist of an infinite number of equally small parts. The mathematical imagination among the ancients must have been very little developed, if such an argument passed muster with minds trained to the investigation of abstract truth.

On the other hand, Newton, perhaps the most exact thinker known to scientific history, has expressed opinions on the constitution of matter closely resembling those of Lucretius. The latter asserts that all substance consists of atoms, which are perfectly solid, and therefore incapable of being crushed or torn apart; for that which has no void within itself can not be separated into parts: moreover, they are exceedingly hard, for otherwise they could not form hard bodies like iron; yet, when combined with "much void," they can give rise to soft substances, as water and air. Compare this statement with Sir Isaac Newton's belief, as expressed in the following terms: "It seems probable that God, in the beginning, formed matter in solid, massy, hard, impenetrable, movable particles of such size, figures, and with such other properties, and in such proportion to space, as most conduced to the end for which he formed them; and that these primitive particles, being solid, are incomparably harder than any porous body compounded of them—even so very hard as never to wear, or to break in pieces." If we except the belief in the creative power of God, this quotation gives us Lucretius's atomic theory in a nutshell.

Our author is again in harmony with the latest deductions of physics, when he asserts that the atoms have in themselves no sensible properties, such as color, heat, etc. But the arguments which he uses to establish this proposition are by no means convincing. His treatment of the atomic motions, however, is the most vulnerable point in his system. He supposed all constituted things to be produced by the impact of atoms, which through all eternity were descending, urged on by their own weight. Now, Lucretius had very clear ideas on the subject of gravitation. He knew that, except when in a resisting medium, all bodies fall with equal velocities. Hence, in this everlasting, downward rain, it would be impossible for one atom to approach another and combine with it. To obviate this difficulty, he conceived a slight lateral motion, by which the particles are brought together. He offers no reason for this extraordinary hypothesis, except that no other supposition can explain the formation of things *so as to accord with his theory*. It is the old story of system first and facts afterward, and shows well the injurious tendency of the *a priori* method in one who was otherwise well fitted for the pursuit of knowledge.

Passing on to his other teachings, we find him devoting a whole book to the bodily sensations. These, he attempts to show, are produced by corporeal images given off from bodies, and coming into contact with our organs of sense. Thus, he thought that all things were giving off thin pellicles of substance, which, by impinging upon the eye, cause the sensation of sight. This is not unlike Newton's emission hypothesis. His theory of sound also is more purely mechanical than that at present accepted. He supposes this sensation to be caused by the direct passage of particles from the source of sound to the

ear, and seems to have had no idea of motion communicated continuously so as to produce waves. His remarks under this general head are often quite correct, and show that he had some capacity for observation.

When treating of the heavenly bodies, he is ordinarily far out of the way. With him the earth is fixed, and the sun and stars revolve about it. With strange perversity, he denies that the orbs of these bodies can be much larger than they appear, no matter at what distance they are placed. On the other hand, in treating this subject he sometimes displays that suspension of judgment which, as opposed to hasty theorizing, is one of the first characteristics of the careful thinker. He himself says: "I assign a number of reasons, one of which must be true; but which among them is true is not for a cautious man to decide."

He next traces the development of man from savagism to civilization; but, though the account is interesting, it has little to do with his views of physical science, and we therefore pass on to the consideration of the remainder of his work, which treats of various natural phenomena, and explains their causes.

He supposes thunder to be produced by the clashing together of clouds, or by the sudden expansion of a volume of air contained in a cloud. This latter action he compares to the bursting of a bladder. Other causes he enumerates, connected with the effects of winds and lightning, whose action on the clouds may produce sound. Lightning, in his view, is struck out like sparks from flint by the friction of the clouds, or it may be caused by the heat generated by the rapid rotation of a hollow cloud.

His views on the cause of water-spouts are similar to those held by many at the present day, namely, that they originate in the vortex of a whirlwind.

His ideas of the nature of clouds are confused, though in one place, at least, he asserts that they are formed by the combination of vapor which is exhaled from the ocean and the earth's surface. The act of raining he ascribes to the compelling force of the winds and the weight of the clouds themselves.

The opinions which he entertains in regard to earthquakes are specially noteworthy, as having been revived of late years by several scientists to explain some, if not all, of the phenomena attendant upon such convulsions of nature. He supposes these to be caused by subterranean downfalls of large masses of rock.

This view has not only been accepted by a number of modern geologists, but also, as Élisée Reclus* remarks, has been corroborated by many observations. To this author we commend the reader who desires to know the various reasons for accepting the theory.

* "The Earth," chapter lxxiv.

The eruption of volcanoes is referred by Lucretius to the expansion of air heated in the cavities of the earth. Modern theorists would rather explain their occurrence by the expansion of steam under great pressure in some underground passage.

Our author goes on with the explanation of many other phenomena. But he is continually led into error by his desire to accommodate the explanation of the effects to suit his theory. As a specimen, we may quote his view of magnetic attraction. According to the Epicurean belief, all substances gave off pellicles or effluvia, which, as before remarked, were supposed to affect the senses. When, then, a magnet and a piece of iron are brought near each other, the effluvia from the former drive away the air between the two bodies, and particles of iron rush to fill the vacuum so caused. Since these particles are very coherent, they draw the rest of the iron after them. The magnet does not attract gold, because that substance is too weighty ; wood, on the other hand, is so porous that the atoms of the effluvia pass through it without difficulty. Amid all these absurdities he seems to have had a really philosophic idea of atmospheric pressure. He says : "The surrounding air is continually dashing upon [bodies] ; and it drives the iron forward, under such circumstances [as those mentioned before], because the space on one side is empty, and receives [the iron] into itself." He seems also to have had a crude idea of the modern germ theory of disease, and this idea he dwells upon in the closing portion of his work. He describes the means by which disease is spread, and instances the plague at Athens,* with a magnificent description of which he concludes his poem.

We have traced such of the principles of the author as seem to bear on the relations of ancient to modern science. We see what effect a false method produced in a man of undoubted genius, endowed with a genuine appreciation of nature and a scientific tendency of mind. Anxious for a rational explanation of every part of the wonderful universe that surrounded him, he was not contented with the slow processes of observation and experiment, but hastened to assign the most probable *a priori* causes to everything. And thus, whenever he states a physical truth, he appears to have stumbled upon it quite accidentally. It is no reproach to modern men of science that they have been anticipated in their discoveries by a Roman who lived nineteen centuries ago. Rather, it is their glory that, for the vague intuitions of the poet-philosopher, they have substituted the certainty of demonstration ; and, by toilsome study in fields which the ancients either neglected or despised, have gained generalizations far surpassing any of his in grandeur. It is not, therefore, for any discoveries that he made, still less for his method of acquiring knowledge, that we give Lucretius a place in the scientific ranks ; it is rather for the high qual-

* Broke out B. C. 430. An accurate account of it is given by Thucydides, from whom Lucretius is thought to have taken his description.

ities of intellect, scientific cast of imagination, and a will that never faltered in the earnest pursuit of truth for its own sake. In every age these are the true characteristics of a man of science.

SKETCH OF MICHEL CHASLES.

"IN the death of Michel Chasles," said M. J. Bertrand, in his funeral eulogy of the deceased mathematician, "France has lost one of its glories, and the members of the Academy of Sciences have lost an excellent friend, who, devoted without reserve to the beautiful studies which made his fame, showed an equal and active kindness to all who traveled in different directions along the highways of science." "As far back as the present generation can remember," says Mr. R. Tucker, in "Nature," "Chasles has been a prince of geometers, and it has come upon many of us as a surprise to hear that he was still walking and working in our midst. . . . To many," says the same writer, "the man who had surpassed in age Leibnitz by seventeen, Euler by eleven, Lagrange by ten, Laplace and Gauss by nine, and Newton by two years, was a '*venerabile nomen*,' but yet a '*nomen*' only."

M. Chasles was born at Epernon, France, November 15, 1793, and died December 18, 1880. His mathematical tastes were exhibited at a very early age; while a pupil in elementary mathematics in the Imperial Lyceum, he was accustomed to communicate to the students in the rival colleges the problems and exercises of each week, asking them, in return, to furnish him the questions proposed by their masters. He entered the École Polytechnique in 1812, and passed out from it with a diploma in engineering in 1814, after having taken his place in the defense of Paris. He was about to go to Chartres to bid farewell to his mother before proceeding to duty at Metz, when he was waited upon by the father of one of his comrades, who asked him to resign in favor of his son, who had failed to obtain a position, pleading that he had made great sacrifices, which he could not afford to repeat, to prepare the youth for a career suited to his taste. Young Chasles made no reply, but went on to Chartres and told his mother he would stay with her. He returned to the École Polytechnique in 1815, but voluntarily renounced public employment, and went to Chartres to spend ten years working quietly at mathematical occupations. "Always," says M. Bertrand, "passionately fond of geometry, he worked out elaborate problems, discovered elegant theorems every day, invented general and fruitful methods, without attracting the attention of the masters of science, or pretending to do so. . . . Without grieving or com-

plaining of his obscurity, or being discouraged by it, he pursued his studies for the love of them, and found glory without having done anything to secure it except to produce great works."

M. Chasles was elected a corresponding member of the Academy in 1839, was appointed Professor of Mechanics and Geodesy in the École Polytechnique in 1841, and was elected the first occupant of the newly created chair of Modern Geometry in 1846. He resigned his position in the École Polytechnique in 1851, in consequence of the introduction into the school of changes of which he did not approve. He was chosen a foreign member of the Royal Society in 1854, was awarded the Copley medal in 1865, and was elected, in 1867, the first foreign member of the London Mathematical Society.

M. Chasles's life was one of active, uninterrupted work in his favorite field, from the time he left the Lyceum till he was eighty-seven years old—a period of sixty-eight years. His contributions of papers to scientific societies and journals are estimated to number nearly two hundred and forty, on subjects which range "over curves and surfaces of the second and any degree, geometry, mechanics (and attractions), history, and astronomy."

Of his greater works—" masterpieces that commanded attention "—the earliest was the " Aperçu Historique," or " Historical View of the Origin and Development of Methods in Geometry," which, says M. Bertrand, " under a title that is more than modest, remains the most learned, the most profound, the most original work that the history of science has ever inspired." It was published in 1830, being an elaboration of a paper contributed several years before to the Royal Academy of Brussels, and was reprinted in 1875, with a preface, giving a short historical account of the book. It is, says Mr. Tucker, a perfect mine of geometrical facts, and is to the present day a high authority on the subject of which it treats.

The courses of lectures delivered by M. Chasles as Professor of Modern Geometry were embodied in 1852 in the " Traité de Géométrie supérieure," or " Treatise on the Higher Geometry," a work which, of late years scarce and high, has recently appeared in a second edition. This was followed by a sequel, a treatise on conic sections (" Traité des Sections Coniques, faisant suite au Traité de Géométrie supérieure," the first volume of which appeared in 1865. The second volume has not been published, but the materials for it have been given from time to time in the " Comptes Rendus."

In 1863 M. Chasles published his " Three Books on the Porisms of Euclid," which was the origin of a short controversy with M. P. Breton. The question of attraction was presented to M. Chasles under several points of view, and gave occasion to a number of memoirs extending even to the consideration of the general problem of the attraction of a body of any form. Poinsot said of one of these papers that it offered a remarkable example of the elegance and light

that geometry could shed on the most obscure and difficult questions; and M. Bertrand has said of them that they gave demonstrations and results admirable as models of elegance and generality.

M. Chasles gained notoriety a few years ago by his connection with a number of manuscripts and autographs purporting to be by distinguished men of the past, among them Galileo, Pascal, Sir Isaac Newton, and even Julius Cæsar and other Roman emperors and the apostles, which he bought of one Irène Lucas and which proved to be nearly all forgeries by that adventurer. Among them were some which claimed for Pascal the merit of Newton's most celebrated discoveries. M. Chasles earnestly defended the authenticity of the documents, of which he was fully and honestly convinced, and was sustained by some eminent members of the Academy, until Lucas was unmistakably shown to have fabricated them. Out of twenty-seven thousand papers which he bought, only about a hundred were genuine.

M. Bertrand, summing up the mathematical work of M. Chasles, says that more than once, without abandoning the geometric method, he "has shown with a rare felicity how all mathematical truths are connected by a close and mysterious bond. We owe to him, in one of the highest and most difficult theories of the integral calculus, elegant theorems admired by analysts; he has added to mechanics a chapter which has become classic on the displacement of solid bodies; he has found in the theory of attraction beautiful and general theorems which have revived the theory of static electricity. . . . All geometricians, without distinction of nationality or school, have bowed before this venerable old man; all have admired his inventive power, his fertility, which age seemed to rejuvenate; his ardor and his zeal continued into his latest days."

LITERARY NOTICES.

Food for the Invalid, the Convalescent, the Dyspeptic, and the Gouty. By J. Milner Fothergill, M. D., and Horatio C. Wood, M. D. New York: Macmillan & Co. 1880. Pp. 150. Price, $1.

The introduction to this volume is a very important and interesting essay on food in its sanitary relations by Dr. Fothergill, while Dr. Wood compiled the recipes, some three hundred in number. In speaking of our present eating arrangements and culinary combinations, Dr. Fothergill says that they have come about under the guidance of the palate first, and the digestion afterward. They were established before the daybreak of physiological knowledge, and the light of chemistry and physiology can not fail to disturb them. Our food combinations should now be modified by our advancing knowledge of the wants of the organism. By a suitable dietary many maladies may be avoided, and many troubles, as indigestion, biliousness, gout, and diabetes, alleviated or even cured. To the increasing wealth and mental worry of our times, Dr. Fothergill ascribes much of the prevalent biliousness, gout, and visceral disturbance; and also the growing incapacity to digest fat, which has led to the use of artificial digestive agents. Hence the necessity for a cook-book devoted to the food of those out of health, or with feeble powers of digestion.

Dr. Fothergill traces the biliousness and gout so common nowadays to the excessive use of albuminoids in our food. They are requisite for tissue growth and repair, and, when swallowed, are digested mainly in the stomach, passing into the blood, whence they reach the tissues. But the nitrogen, their essential feature, when in combination with hydrogen and carbon, does not readily oxidize, and it is the imperfect oxidation in the liver of this nitrogen of the surplus albuminoids that causes biliousness and the gouty condition. "In biliousness the blood is surcharged with bile-salts of albuminoid descent and nitrogenized lineage; just as much as the lithic acid now known as 'gout-poison,' . . . and it is obvious that in the treatment of biliousness and gout alike it is essential to cut down the albuminoid elements of the food to the minimum of tissue-wants."

To the question why we systematically eat more albuminoid food than we require, Dr. Fothergill replies that there are two very potent reasons: one, because it is pleasant to eat it, and another, because it produces an agreeable mental condition. "The albuminoid waste in the blood gives us the sensation of energy, of being equal to work, which is pleasant to all. But this sensation is bought with a price; and its Nemesis is found in biliousness and gout." After proving the albuminoid descent of both bile and gout-poison, Dr. Fothergill remarks that the amount of albuminoids required for the repair of the tissues of the body is very small, and it is with the intent of avoiding excessive albuminoid waste that the dietaries arranged in the volume consist so little of "brown meats." The flesh of fish, however, is provided for in abundance. More than ninety of the recipes are devoted to the preparation of fish of various kinds in soups, pies, patties, and puddings, or boiled, stewed, fried, broiled, in paste, and on toast. Not that "fish" differs materially from "flesh" in chemical composition, but it contains more water, and is more easily digestible. "A meal of fish," it is said, "gives less albuminoid waste than a meal of brown meats."

Great prominence is given to fat in the dishes here recommended. It is regarded as a most important element of food, and much pains are taken to make it unobjectionable to the palate, inoffensive to the stomach, and easily assimilable by the system. Starch, also, so long decried and sneered at as having no food-value, is given a prominent place. "With fat and starch," Dr. Fothergill declares, "the bilious are comparatively well; for neither can produce bile-acids." They may, however, lead indirectly to the production of bile-acids when eaten in excess.

The first forty-three recipes of the book

are for drinks of various kinds—milk with seltzer-water, with lime, with magnesia, etc., teas, broths, gruels, egg preparations, lemonade, and a long list of variously flavored "waters." When we come to the solid foods, the reader is furnished with a guide to their use by means of initials attached to the recipes. I. stands for invalid, C. for convalescent, D. for dyspeptic, G. for gouty, and E. for economical. When a dish is suitable for all these classes, all these initials are appended to it. Thus, mock *pâté de foie gras* is marked (I. C. D. G. E.), cauliflower (C. G.), scrambled eggs (I. C. D.), while half a dozen recipes for various salads have only the single initial (G.)

Cream is also a favorite element in many of the recipes of this book. Eggs, oysters, fruit, and vegetables abound in them; and, although the title only promises sick-room cookery, we are offered an abundance, and variety that commend the book to everybody, sick or well. Warmed-over meat is condemned, unless the digestion is perfect. One method of preparing it is given as follows: "Mince the meat fine with some pepper and salt; place a wall of well-mashed potato in a pie-dish or soup-plate; put in the minced-meat, and place over it a crust of mashed potato; put in the oven till the meat is warmed through, and not one moment longer." Sandwiches are much approved. Nursery-food is carefully provided for, and excellent general directions are given concerning the serving of food to the sick. The book can not fail to be helpful to families which are seldom quite exempt from sickness or feebleness; and physicians may make it serviceable in providing a full dietary for their patients.

Introduction to the Study of Indian Languages, with Words, Phrases, and Sentences to be collected. By J. W. Powell. Second edition, with Charts. Washington: Government Printing-Office. Pp. 228, with blanks for taking Notes.

This work, published under the direction of the Bureau of Ethnography of the Smithsonian Institution, is designed to aid in the collection of data for the examination and comparison of the languages and dialects of the Indian tribes, and to direct the efforts of students among whatever tribe, so that they shall be conducted methodically, and adapted to fit a system embracing the whole subject. The first edition was published in 1877; the present edition embodies the modifications of the plan that have been suggested by the progress that has been made in the study. An alphabet has been prepared which seems to admit of the representation of all the sounds and modifications of sounds that are likely to occur without demanding the use of odd signs or going outside of the cases of a well-stocked English printing-office. A chapter is devoted to the explanation of the manners, customs, articles of dress, ornament, and use, etc., the study of which may throw light upon the main subject, and should be connected with it. This chapter contains also a synopsis of Mr. Lewis H. Morgan's work on kinship and affinity, illustrated by charts showing the relations of kinship for nine generations, and gives the substance of a paper by Mr. J. Hammond Trumbull on the best methods of studying the Indian languages. It is followed by a series of schedules embracing the various subjects of Indian thought which are to be filled up by individual students with details for vocabularies, phrases, the representation of inflections, and all other matter that may be of value in the study.

Report on the Geology of the High Plateaus of Utah. With Atlas. By C. E. Dutton, Captain of Ordnance, U. S. A. Washington: Government Printing-Office. Pp. 307.

The surveys, of which this report gives an account, were conducted, in 1875, 1876, and 1877, in connection with the surveys of Major J. W. Powell, and under his direction. The Colorado plateaus, of which the district covered by the survey is a part, extend from southern Wyoming through western Colorado and eastern Utah far into New Mexico and Arizona, and have a general elevation of about seven thousand feet above the sea, but which varies from five thousand to twelve thousand feet. The high plateaus constitute one of the most important of the several groups into which the region is divided, and occupy a belt of country extending from a point about fifteen miles east of Mount Nebo in the Wahsatch Mountains for about one hundred and seventy-five miles to

the south-southwest, and having a breadth of from twenty-five to eighty miles, and a total area approaching nine thousand square miles. They are distinct, structurally and topographically, from the Wahsatch range, belong to another age, and are wholly different in their forms and geological relations. They are composed of early Tertiary and late Cretaceous formations, nearly or quite horizontal, and usually capped with lava formations of exceedingly complex arrangement. The region is for the most part destitute of vegetation and soil, and dissected by deep cañons. Consequently, its geology, as a whole, is plainly revealed, so that every fault, every flexure, the relations of successive unconformities, and all facts of structure are seen at once; but two sources of obscurity exist, in that some of the highest plateaus are covered with forests and vegetation, and that the extravasated rocks are aggregated in a more confused manner than the sedimentary beds, so that uncertainties and doubts still remain after the utmost labor and care in tracing them. The surface of the plateaus appears to have formed the bottom of a lake in Eocene times, and to have gradually risen to its present height by a movement which may still be going on. The drainage is by the tributaries of the Colorado, whose channels were formed in the lake-bottom before it was wholly dry, and have kept their course and level where they are, "in spite of faults, flexures, and swells, in spite of mountains and plateaus," the streams turning neither to the right nor to the left as these irregularities were encountered, but persistently cutting their way through the same old places, till the present magnificent cañons have been carved out. Another salient feature of the region is given by the extraordinarily extensive faults, the results of displacements which took place in relatively recent times. Some five or six of these great displacements are from twenty to a hundred miles long, and are of heights rising to a maximum of five thousand feet. One of them, the Eastern Kaibab fault, is the longest line of displacement of which the author has any knowledge; it has a length which can not fall much short of three hundred miles, and may be found to exceed that after its termini have been discovered, and a maximum height of seven thousand feet. The displacements do not belong wholly to any one period, but are of distinct though not widely separated ages. The erosions of the plateau do not appear to have been affected by the presence of ice during the glacial epoch, but the evidence is strongly in favor of the conclusion that the climate in this district was not glacial. "The ravines and valleys are conspicuously water-carved, and conspicuously *not* ice-carved." Yet evidences of the former existence of small local glaciers are found on the summits of the cliffs, not less than eight thousand five hundred to nine thousand feet high; and this is believed to emphasize the evidence of the absence of ice-action in the valleys and plateau flanks.

The region is one of extinct volcanism, the action of which, though small compared with that we know of some other regions, has been great compared with what is seen in most of the volcanic districts of Europe. The phenomena are of the most varied kinds, and relate to eruptions of which the oldest go back to the middle Eocene, while the latest "can not be as old as the Christian era," and "it is hard to believe that they are as old as the conquest of Mexico by Cortes." They are subjected to a careful study, especially with reference to the order of succession of the eruptions, and a comparison of the same with the arrangement proposed by Baron Richtofen. This study is followed by a discussion of the origin of volcanic eruptions, as illustrated by these phenomena. The photographic work not having been completed, has not been embodied in the present volume. The text is more especially devoted to the general geology, while many of the details are made more clear by heliotypic illustrations than they can be by mere textual descriptions. The atlas contains topographical, geological, and relief maps, and a sheet showing the arrangement of the faults and flexures.

The Power of Movement in Plants. By Charles Darwin, LL. D., F. R. S., assisted by Francis Darwin. With Illustrations. New York: D. Appleton & Co. 1881. Pp. 592. Price, $2.00.

Mr. Darwin's latest study of plant-life shows no abatement of his power of work or his habits of fresh and original observation. We have learned to expect from him at intervals, never much prolonged, the re-

sults of special research in some by-path or other subordinated to the main course of the biological system associated with his name; and it has been an unfailing source of interest to see the central ideas of the evolution and the continuity of life developed in detail through a series of special treatises, each wellnigh exhaustive of the materials available for its subject. It is in the department of plant-life that he has of late years devoted himself to working out the laws which govern the whole realm of vital phenomena. That these laws in their origin and ultimate operation are common to plant and animal alike has long formed a characteristic principle or axiom of his philosophy. In the experimental study needed for the elaboration of the vital processes and the making good the resulting generalizations, the kingdom of plant-life offers decided advantages beyond that of animals, if it were only that observations of this class are free from all possible taint of inhumanity. Mr. Darwin has in the quietude of his hothouse, and with a boundless variety of forms for selection, experimented upon the vital organism of plants, seconded by the untiring energy and patience of his son. Night and day seem to have come alike to the aid of this enthusiastic pair of naturalists. The electric light has served them on the failure of the sun's beams, and has in truth opened up of itself a wholly new field for observation as regards the agency of light upon the phenomena of life. To the vista of knowledge revealed by these experiments upon the elementary processes of life in movement, growth, nutrition, respiration, sensation, etc., imagination can set no bounds. It is impossible, Mr. Darwin remarks at the close of his record of these interesting experiments, not to be struck with the resemblance between the foregoing movements of plants and many of the actions performed unconsciously by the lower animals. This analogy has been made the subject of much interesting investigation by Sachs, Frank, and other leading biologists on the Continent, and we may expect that the highly original and elaborate experiments recorded in the volume before us will give fresh stimulus to this most important course of investigation, laying as they do a new and more solid basis for the comparative study of plant and animal life. Plants, of course, possess neither nerves nor a central nervous system, and there is consequently lacking in them that which gives its most distinctive character to animal life as a whole. Yet that sensitive impressions are present in plants, with the power of movement in obedience to the stimulus thereby imparted to the organism, may be held to be conclusively shown by facts such as those produced by Mr. Darwin. Most striking of all, he urges, as a point of resemblance, is the localization of their sensitiveness, and the transmission of an influence from the excited part to another, which consequently moves. May it not be inferred that in animals the nervous structures serve merely for the more perfect transmission of impressions and for the more complete intercommunication of parts? From the earliest sign of germination in plants—namely, the protrusion of the radicle from the seed-coats under the soil—there is manifest a sensitiveness to external influences, with a movement in response to the conditions of light or pressure, etc., which is not sharply to be distinguished from the rudimentary intelligence in animals. In the sensitive point or tip of the radicle, which we might compare with the antennæ in insects, there is to be seen an organic power equivalent, in a lesser degree, to the action of the brain in the lower animals:

> We believe that there is no structure in plants more wonderful, as far as its functions are concerned, than the tip of the radicle. If the tip be lightly pressed or burned or cut, it transmits an influence to the upper adjoining part, causing it to bend away from the affected side; and, what is more surprising, the tip can distinguish between a slightly harder and softer object, by which it is simultaneously pressed on opposite sides. If, however, the radicle is pressed by a similar object a little above the tip, the pressed part does not transmit any influence to the more distant parts, but bends abruptly toward the object. If the tip perceives the air to be moister on one side than on the other, it likewise transmits an influence to the upper adjoining part, which bends toward the source of moisture. When the tip is excited by light (though in the case of radicles this was ascertained in only a single instance) the adjoining part bends from the light; but when excited by gravitation the same part bends toward the center of gravity. In almost every case we can clearly perceive the final purpose or advantage of the several movements. Two, or perhaps more, of the exciting causes often act simultaneously on the tip, and one conquers the other, no doubt in accordance with its importance for the

life of the plant. The course pursued by the radicle in penetrating the ground must be determined by the tip; hence it has acquired such diverse kinds of sensitiveness. It is hardly an exaggeration to say that the tip of the radicle thus endowed, and having the power of directing the movements of the adjoining parts, acts like the brain of one of the lower animals; the brain being seated within the anterior end of the body, receiving impressions from the sense-organs, and directing the several movements.

In this suggestive passage, with which our authors bring their present course of investigations to a close, we see opened up a far-reaching prospect for the biological progress of the future. For the present it must suffice to have made good so much as our authors have been able to report from their patient study of the simpler and more easily observable vital phenomena.

A great part of Mr. Darwin's work is taken up with the details of experiments for measuring the quantity and direction of motion in plants, both under natural and artificial conditions. Direct observations have been made in numerous cases under the microscope, and in others use has been made of delicate apparatus of various kinds. Minute bits of card or tissue paper have been attached to the radicles, filaments, or terminals of stems, and tiny particles of metal or beads of shellac have been employed as weights to test the power of rigidity or of sensitiveness in the fibers of plants. Pins stuck in the soil around the stem have served to mark the conduct of the plant when impeded in its growth or its spontaneous habits of movement. The movements of the tenderest filaments or leaflets have been made to trace themselves in lines upon smoked glass. A series of diagrams has in this way been worked out, and set before the eye in numerous woodcuts, generally magnified two or three fold, showing the general law of circumnutation indefinitely modified by special conditions. The differences of movement in seedling and mature plants, in monocotyledons and dicotyledons, with the indications of certain movements having been acquired for a special purpose, are pursued through widely contrasted classes of plants. The circumnutating powers of young leaves are described in thirty-three genera belonging to twenty-five families, widely distributed among ordinary and gymnospermous dicotyledons, and among monocotyledons, together with many cryptogams. Here the seat of movement is generally seen to lie in the petiole, but sometimes both in the petiole and the blade, or in the blade alone. The movement is chiefly in a vertical plane; yet, as the ascending and descending lines never coincide, there is always some lateral movement, resulting in irregular ellipses, so that the motion becomes really one of circumnutation. It is interesting to mark the periodicity of leaf-movement, a gentle rise being observed in the evening and the early part of the night, with a sinking toward morning. In *Dionæa* and certain *graminiæ*, a strange jerking and oscillatory movement is to be seen under the microscope, curiously contrasted with the immobility of the tentacles of *Drosera rotundifolia*, which are yet sensitive enough to curl inward in twenty-three seconds so as to absorb a bit of raw meat. The distinction of epinastic and hyponastic growth—according as the growth takes place more rapidly in the upper or lower surface of an organ, causing it to bend downward or upward respectively—introduced by De Vries, has been illustrated in the case of a number of plants. To Frank is due the introduction of the useful terms of "heliotropism," for the tendency to turn to the light, with its correlative "apheliotropism," the opposite tendency, occasionally to be observed, "geotropism," for the bending toward the earth, and "apogeotropism," expressing motion in opposition to gravity or from the center of the earth. For the measurement of movements, sometimes excessively minute, various expedients were adopted. Dots were made from time to time upon sheets of glass placed vertically and horizontally near the plant, these dots being then copied on tracing-paper and joined by ruled lines, arrows being added to show the direction of the movement. The plants were exposed to varied conditions of light, sometimes being wholly protected, the light at other times being admitted from above or from either side. In addition to the sun's rays, the electric light was made the subject of experiment, with results comparable with those of Dr. Siemens. A valuable chapter is given to the sensitiveness of plants to light, with its transmitted effects. That growth in general is checked by light, which acts upon

plants much in the same manner as it does upon the nervous system in animals, is a statement which needs to be reconciled with the undoubted fact that the power of bending to the light is beneficial to plants, and may in all probability have been specially acquired under the action of natural selection. Experiments have abundantly shown that growth is exceptionally promoted by light continuously kept up, as in the polar summer, or when the absence of sunlight is compensated by the electric ray. Herein is, of course, involved the intricate problem of the sleep of plants, which is carried on through two chapters of the highest interest.—*Saturday Review.*

Guide to the Study of Political Economy. By Dr. Luigi Cossa. Translated from the second Italian edition. With a Preface by W. Stanley Jevons, F. R. S. London: Macmillan & Co. 1880. Pp. 237. Price, $1.25.

This is a work which no English student of economics can fail to find of the greatest value, in helping him to a knowledge of the extent and worth of the economic writings of foreign authors. Dr. Cossa is peculiarly fitted, by his wide acquaintance with economic literature and by his breadth of view, to make a competent and trustworthy guide, and the translation of his work into the chief European languages sufficiently attests its merit. The work comprehends a brief exposition of the scope, character, and method of the science, with an historical review of its position and doctrines in ancient and modern times, and a long list of the writings of economists of all countries, with indications of their worth. In the first chapter the science is defined and its demarkation from allied branches of knowledge pointed out. The division of the science and its relation to other sciences occupy the author in the next two chapters, the views of a number of leading economists being given. The chapter upon method contains a brief but excellent discussion of the questions involved in the controversy between what are known as the historical and philosophic schools, Dr. Cossa pointing out the error of main position of the former school, while admitting the value of much of the work accomplished by its members. A consideration of the importance of the science and an examination of some of the objections to it complete the more general part of the work, the remainder being devoted to the historical review. This includes a notice of the political economy of the ancients, of the middle ages, and of modern times, treating briefly in the latter period of that of the physiocrats, of Adam Smith and his successors, of the economists of the present century, and closing with a consideration of contemporary Italian economists. An index of the authors quoted in the text is placed at the close of the volume, the list containing over seven hundred names.

The Young Folks' Cyclopædia of Persons and Places. By John D. Champlin, Jr., late Associate Editor of the "American Cyclopædia." With numerous Illustrations. New York: Henry Holt & Co. 1881. Pp. 936. Price, $3.50.

This work, including both real and fabulous persons and places, is intended, in connection with the "Young Folks' Cyclopædia of Common Things" by the same author, to cover the usual range of cyclopedic knowledge. The language is simple; technical terms where admitted are explained; the illustrations are selected to exclude those common in school-books, and preference is given to those showing restorations of classic scenes and famous buildings. The pronunciations are indicated approximately by plain English letters; and the size of countries and cities is made more plain by comparing them with States and towns at home. Most of the facts are brought down to 1880.

James Smithson and his Bequest, by William J. Rhees; and The Scientific Writings of James Smithson, edited by William J. Rhees. Washington: Published by the Smithsonian Institution. 1879. Pp. 227.

The preparation of a biography of the founder of the Smithsonian Institution has been delayed on account of the scantiness of the materials. Unusual exertions were made last year to collect the facts and incidents of the life of Mr. Smithson, but nothing new was elicited. The few facts which are known have been collected by Mr. Rhees as all the information likely to be obtained, and are presented for the first time as an authentic account of the man

who crowned a well-earned reputation for scientific attainments with his remarkable bequest for the increase and diffusion of knowledge among men. Three portraits of Mr. Smithson and a view of his tomb at Genoa lend attractions to the work.

The volume contains, of Smithson's scientific writings, twenty-seven papers, mostly on chemical subjects, which were published in the "Transactions of the Royal Society of London," and Thomson's "Annals of Philosophy," between 1791 and 1825, with reviews of the scientific character of the papers by Professor Walter R. Johnson and J. R. McD. Irby. Mr. Smithson left, in addition to these papers, several hundred manuscripts, scraps, and notes on many subjects, which were destroyed in the fire at the Smithsonian Building in 1865.

Report on the Culture of the Sugar-Beet and the Manufacture of Sugar therefrom in France and the United States. By William McMurtrie, E. M., Ph. D., Superintendent of Agriculture in the United States Section, and Agent and Representative of the United States Department of Agriculture, at the Paris Exposition of 1878. Washington: Government Printing-Office. 1880. Pp. 294.

Mr. McMurtrie took advantage of his visit to the Paris Exposition to secure full information concerning the methods of culture of the beet and manufacture of sugar followed in France, and the same is given here, with additional information from other countries in Europe. The conditions most favorable to the success of the beet-sugar enterprise appear to be a mean temperature of not more than 70° and a minimum average rainfall of above two inches during the summer months. Tables, with illustrative charts, are given, showing in what parts of the United States these conditions exist. Full detailed reports are added of the progress and present condition of the sugar-beet culture in the New England States, particularly in Maine. The machinery used in making the sugar is illustrated by descriptive cuts.

Sanskrit and its Kindred Literatures. Studies in Comparative Mythology. By Laura Elizabeth Poor. Boston: Roberts Brothers. 1880. Pp. 468. Price, $2.

The object of the author has been to interest people in the study of all literature on the new basis which has been laid by the sciences of comparative philology and comparative mythology; to show that literature is one and continuous; that the same leading ideas have arisen at epochs apparently far separated from each other; and that each nation, however isolated it may seem, is, in reality, a link in the great chain of development of the human mind. The most prominence is given to Sanskrit as the oldest and nearest to the foundation of the Aryan literatures, which is viewed in its Vedic and Buddhist aspects, and in the light of the greatest works in either branch. A notice of the ancient Persian literature and the Zendavesta follows, after which are chapters on Greek mythology, poetry, drama, philosophy, and history, Latin and Keltic, Scandinavian, Anglo-Saxon, and German literatures, mediæval hymns and ballads, the mythology of Slavonic literature, and the modern poetry of Europe.

High Schools. By B. G. Northrop, Secretary of the Connecticut Board of Education. Syracuse, N. Y.: Davis, Bardeen & Co. Paper. Pp. 26. Price, 25 cents.

Mr. Northrop in this pamphlet essays to answer the objections that have been urged during a few years past against the continuance of the public high schools. To the objection that they are an excrescence on our school system, aside from the design of its founders, he replies that they have been maintained in Massachusetts for a longer time and on a broader scale than in any other state of the world, the first law establishing them having been passed in 1647. He urges that the high school lifts up all the schools of lower grades by giving increased efficiency to them through its standard of admission, which presents a strong stimulus to studiousness and fidelity. It is true that only a small proportion of college students have received their preliminary training in the high schools, but it is claimed on the other side that the interest of a large proportion of the students in higher education was first excited in the high schools, and that they have gone out from them to the academies where they have received their special preparation. That the high schools have not a communistic tendency, as some assert, is proved by the fact that communism prevails

least where they are the most flourishing; they are not in the nature of a charity, as some seem to believe, but are an assertion of the right of the State to demand that its people should have the education necessary to its preservation and prosperity. Much of the opposition to high schools has arisen from mistakes that have been made in their management. They should not undertake to teach Latin and Greek, or other branches that the pupil may not have occasion or opportunity to apply or continue in after-life, but should aim rather to teach him how to study, and to inspire him with love of learning.

The Geological and Natural History of Minnesota. The Eighth Annual Report, for the Year 1879. St. Paul: the Pioneer-Press Company. 1880. Pp. 183.

The year's work of surveys was carried on chiefly in the northern part of the State, and resulted in the extension of the surveyed area in northeastern Minnesota, except as to some points on the Cascade River, as far west as the Poplar River, and over a considerable district west of that stream. Studies have also been made of the drift-covered counties in the central and western part of the State, with especial reference to their topography, glacial geology, and economic resources. Collections have been made of animals and plants on the shores of Lake Superior, and a partial catalogue of species of birds is given.

Ninth Report of the State Entomologist on the Noxious and Beneficial Insects of the State of Illinois. Fourth Annual Report by Cyrus Thomas, Ph. D. Springfield, Illinois: Weber & Co., State Printers. Pp. 142.

The increasing demand for the State Entomological Reports is regarded as indicating that farmers and horticulturists are paying more attention to entomology than formerly, and attests the usefulness of the office of State Entomologist. The present report gives especial attention to the history of the European cabbage-worm; and, though the author considers it a diversion from his legitimate field, in answer to repeated requests furnishes information in reference to parasites infesting domestic animals.

Abridgment of the Nautical Almanac for 1881. Philadelphia: Riggs & Brother. Pp. 150. Price, 25 cents.

Besides the hydrographic notices, the rules of the road at sea, and the catalogue of lighthouses, this abridgment contains an important paper on maritime meteorology, by Professor Thompson B. Maury. The paper embraces a synopsis of the nature and direction of the prevailing winds of the Atlantic coast and ocean, and of the laws that appear to govern the course of hurricanes; to which are added hints for handling ships in or near cyclones, by the observance of which shipmasters may be enabled to decide upon and pursue the course most likely to insure the safety of their vessels.

Mr. Henry George has in the press of D. Appleton & Co., and will shortly publish, a new book, entitled "The Irish Land Question: What it involves, and how alone it can be settled."

PUBLICATIONS RECEIVED.

The Causes which produce the Great Prevailing Winds and Ocean-Currents, and their Effects on Climate. By C. A. M. Taber. Boston: David Clapp & Son, printers. 1881. Pp. 54.

Report on the Marine Isopoda of New England and Adjacent Waters. By Oscar Harger. Pp. 166, with Thirteen Plates. From the Report of the United States Commissioner of Fish and Fisheries. Part VI for 1878.

The Development of Osseous Callus in Fractures of the Bones of Man and Animals. By Henry O. Marcy, M. D. Philadelphia: Collins's printing-house. 1880. Pp. 20.

Report of the Analysis of the Ohio River Water. By C. R. Stuntz, M. D. Cincinnati; Robert Clarke & Co. 1881. Pp. 29.

Dr. Edward Jenner's Discovery of Vaccination. By E. L. B. Godfrey, M. D. Philadelphia: Hoeflich & Senseman, printers. Pp. 16.

Higher Education of Medical Men. By F. D. Lente, M. D. New York: C. L. Birmingham & Co. 1881. Pp. 16.

A Syllabus of Anglo-Saxon Literature. By J. M. Hart, University of Cincinnati. Cincinnati: Robert Clarke & Co. 1881. Pp. 69.

The Strong Galvanic Current in the Treatment of Sciatica. By V. P. Gibney, M. D. Philadelphia: Collins, printer. 1880. Pp. 11.

Second Biennial Report of the Superintendent of Public Instruction of the State of Colorado. Denver, Colorado: Tribune Publishing Co. 1881. Pp. 133.

Nasal Catarrh and Ozæna. By George Pyburn, M. D. Sacramento, California: Day & Joy, printers. 1881. Pp. 16.

Clinical Anatomy of the Lower Extremity. By W. W. Keen, M. D., of Philadelphia. Illustrated. Brooklyn, New York. 1881. Pp. 20.

The Structure and Affinities of Euphoberia: a Genus of Carboniferous Myriapoda. By Samuel H. Scudder. Reprint from the "American Journal of Science." Pp. 5.

Tidal Theory of the Forms of Comets. By George W. Coakley. Salem, Massachusetts. 1880. Pp. 18.

"Papilio." Organ of the New York Entomological Club. Vol. I, No. 1. New York. January, 1881. Pp. 12. Subscription, $2 per annum (ten numbers).

Third Annual Announcement of the Normal and Scientific School, Morris, Illinois. Morris. 1880. Pp. 22.

On the Constitution of the Naphthalines and their Derivatives. By M. M. F. Reverdin and E. Notting. Translated from the German by M. Benjamin, Ph. B., and T. Tonnele, Ph. B. Pp. 8.

Indications of Character in the Head and Face. By H. S. Drayton, A. M. Illustrated. New York: Fowler & Wells. 1881. Pp. 48. Price, 15 cents.

Pueblo Pottery. By F. W. Putnam. From the "American Art Review" for February, 1881. Illustrated. Pp 4.

The Spirit of Education. By M. l'Abbé Amable Béesau. Translated by Mrs. E. M. McCarthy. Syracuse. New York: C. W. Bardeen. 1881. Pp. 325. $1.25.

Reminiscences of Dr. Spurzheim and George Combe. By Nahum Capen. LL. D. New York: Fowler & Wells. 1881. Pp. 262. $1.50.

Drugs that enslave. The Opium, Morphine, Chloral, and Hashisch Habits. By H. H. Kane, M. D. Philadelphia: Presley Blakiston. 1881. Pp. 224. $1.50.

First German Book. After the Natural or Pestalozzian Method. By James H. Worman, A. M. New York and Chicago: A. S. Barnes & Co. Pp. 63. 35 cents, post-paid.

The Baldwin Locomotive Works. Illustrated. Philadelphia: J. B. Lippincott & Co. 1881. Pp. 153. $5.

The Human Body: An Account of its Structure and Activities, and the Conditions of its Healthy Working. By H. Newell Marten, D. Sc., etc. Illustrated. New York: Henry Holt & Co. 1881. Pp. 655. $1.75.

POPULAR MISCELLANY.

An Epidemic of Hystero-Demonomania.—An Italian physician, Dr. Franzolini, has published an account of an hystero-demoniac epidemic which prevailed in the rural district of Verzeguis, province of Friuli, Italy, in 1878, and which he and Dr. Chiap were commissioned by the Prefect of Udine to examine. The commune contains about eighteen hundred inhabitants, of whom, at the time the inquest was made, sixty-two women and eleven men in two of its four subdivisions were sick, the majority of them with nervous affections of different degrees of intensity, and generally of the hysteric form without convulsions or delirium. The people of the commune were of inferior intellectual capacity and development, enjoyed little communication with the world, had been in the habit of intermarrying with each other and often with relatives of the third and fourth degrees, and were uneducated, and greatly under the influence of the priests. In November, 1877, previous to the appearance of the disease, the Jesuits had conducted a mission in the commune, with exercises and services occupying nearly all the time for several days. A general, intense religious excitement was thus produced. Two months afterward, Margherita Vidusson, a delicate girl twenty-six years old, who had already had hysteric symptoms, supposed to arise from simple nervous disease, for eight years, was attacked with convulsive fits, accompanied with lamentations and cries, which were repeated with varying frequency, intensity, and duration. Sometimes she would have ten or twelve short and quite distinct attacks in a day; at other times the attacks would continue through the day and night, with alternative remissions and exacerbations. The most intense attacks corresponded with the catamenial period. Physical remedies were employed at first against the disease, but the girl was at last believed to be supernaturally possessed, and the priests were called in to practice their exorcisms upon her. The affection then seemed to become more violent and its manifestations to assume a more dramatic form after each priestly visitation. A second person was attacked in a similar manner in July, 1878, then a third and a fourth. A commission of priests was sent to examine into the cases, a solemn mass was held, and other exercises were instituted, after which the malady took a new start and became epidemic. Drs. Franzolini and Chiap were appointed at this time to investigate the character of the disease, and suggest measures for arresting it. They found eighteen persons suffering from violent attacks, all of whom were of marriageable ages, from seventeen to twenty-six years old; one was forty-five, another fifty-five, and a third sixty-three. The symptoms of hysteria in its most simple form, without convulsions or mental aberration, had been observed in all of them for from one or two to five or ten years before the development of the morbid form. In some of them the symptoms of the former form ceased on the appearance of those of the latter. At a given moment in the course of the simple form, new symptoms

would appear which might have passed at first for a graver form of the preëxisting symptoms. From a stage marked by convulsive cries, the patients would fall into a kind of swoon in which consciousness failed and speech became more or less difficult and finally impossible; or the attack would be continued with a kind of mental exaltation in which, without being conscious of it, the patients would indulge in conversations having all the characteristics of the delirium of mania, in some cases of that of demonomania. They would speak in the third person and as if they were men, clearly giving it to be understood that it was not they that spoke, but some other spiritual person—a demon, who used their organs to express what they seemed to say and to execute what they seemed to do. When asked who they were, they would not give their own name, but some strange man's name, which was an epithet rather than a name, and belonged to the demon that possessed them, adding that he had lived in their bodies for months or years, and before that had lived in the body of a person in some other country. Some, in their fits, declared themselves to be witches or diviners, and pretended to answer all sorts of questions and to predict events; the more they were excited by the curiosity or credulity of those who inquired of them, the more ardent they seemed to be to predict and lie with impudence. Blasphemies and imprecations characterized all the attacks, but no appearance of amorousness was shown. Sometimes the patients spoke in Italian instead of in their native Friulian dialect, and witnesses who can hardly be depended upon asserted that some of them spoke in French and Latin. After the attacks some remained sleepy and exhausted, others recovered their natural physical energy and resumed their ordinary occupations, as if they were in good health. At the same time, a certain mental exaltation remained, with the latter class especially, and was revealed by a loquacity, an impertinence, and a boldness in strong contrast with the ordinary excessive timidity of mountain-girls in the presence of strangers. They would laugh without cause and without restraint when questioned respecting their affliction, and protested that they recollected nothing of what they had done in their fits, seeming to believe that they were not sick, but possessed. The attacks were provoked in the majority of cases by the sound of the church-bells: some pretended that the sound operated as a natural exorcism upon the evil spirits of the air; others asserted that the consecration of the host, which was announced by ringing the bells, was the real determining cause of their attacks. The malady was generally aggravated after religious ceremonies, such as masses and pilgrimages; nevertheless, with some, the contact of a sacred relic applied by a priest to the neck or breast was enough immediately to arrest the attack. The means employed to put a stop to the epidemic embraced the instruction of the population against their superstitious beliefs, the discouragement of the exciting religious exercises, exorcisms, and pilgrimages, the isolation of the sick and their dispersion into neighboring districts, so as to prevent them from making a spectacle of themselves, and the institution of a regular medical visitation. The epidemic character of the disease was arrested, and the attacks suffered by the patients became less frequent and violent; but some of the number who were sent home from the hospital at Udine became worse again after their return. A more rigorous application of remedial measures was urged, the operation of which Dr. Franzolini promises to describe in another report.

The Strawberry-Leaf Beetle.—A new destructive insect has been described by Professor A. J. Cook, of Illinois, as preying on the leaves of the strawberry-plant. It is described as the *Paria aterrima*, or strawberry-leaf beetle, and belongs to the family *Chrysomelidæ*, the same to which the Colorado potato-beetle and the grape-vine and cabbage flea-beetles belong. It is about an eighth of an inch long, with yellowish head, antennæ, legs, and wing-cases, brown thorax, clouded with black at the center, and body black on the under side. The yellowish wing-cases have also two black spots, of which the hinder one is the larger. The species is at least two-brooded, appearing first in March, April, and May, and again in July, and may possibly be still more prolific. The larva is white, with

a yellowish head and brown jaws, eleven segments back of the head, the breathing mouths showing plainly along the side of the body, and is ·22 of an inch long. The insects are voracious feeders, and numerous enough to strip the strawberry-plants completely of leaves in the spring and after harvest. The larvæ eat the young roots. Both the larvæ and the pupæ harbor in the earth about the roots of the plants.

Singular Powers in Birds.—Mr. A. D. Bartlett, of the London Zoölogical Society's gardens, has called attention to the singular fact, heretofore unnoticed, that certain birds have the power of ejecting the inner linings as well as the contents of their stomachs. He first noticed this peculiarity when a wrinkled hornbill (*Buceros corrugatus*) in the gardens was observed to have thrown up a closed bag resembling a fig, which seemed to be the inner lining of the gizzard, being "somewhat tough, elastic, and gelatinous," and contained plums or grapes well packed together. He submitted the ejection to Dr. Murie, who regarded it as a result of disease, and expressed surprise that the bird should have lived and been able to feed after having made it. Another perfect specimen of the same kind was obtained a few days afterward and preserved. Others were noticed, all from the same bird, but they were destroyed by other birds in the same cage before they could be saved. Mr. Bartlett rejects the view that the ejection is a sign of disease, and is satisfied that it is a natural secretion provided for the bird during the breeding-season, and is the means by which the male hornbill supplies the female bird during the time he keeps her imprisoned, while she is sitting on her eggs. His opinion is supported by the observations of travelers on the habits of hornbills. The Rev. J. Mason says that, in Burmah, the male bird shuts the female in her nest in a hollow of a tree by plastering up the opening with mud, leaving only a place through which she can put her head, and guards her there; while, to compensate her for the loss of her freedom, he "is ever on the alert to gratify his dainty mistress, who compels him to bring all her viands unbroken, for if a fig or any fruit is injured she will not touch it." Mr. Wallace also has observed that the entrance to the nest of this bird is stopped up with mud and gummy substances. Dr. Livingstone states that when in Kolobeng, South Africa, his attention was directed to the nest of a hornbill, and he, looking, "saw a slit only, about half an inch wide, and three or four inches long, in a slight hollow of the tree." The natives gave an account of the imprisonment of the female bird similar to that related by Mr. Mason, and added that the male continued to feed her and her young family till the young were fully fledged, or for a period of two or three months. "The prisoner," Dr. Livingstone adds, "generally becomes quite fat, and is esteemed a very dainty morsel by the natives, while the poor slave of a husband gets so lean that on the sudden lowering of the temperature, which sometimes happens after a fall of rain, he is benumbed, falls down, and dies." Such exhaustion would result naturally from the draft of repeated ejections upon the vital forces. It is well known that parrots, pigeons, and other birds, reproduce their partially digested food during the pairing and breeding season. The male hornbill has the same habit, and a concave hornbill in the gardens "will frequently throw up grapes, and, holding them in the point of the bill, will throw them into the mouth of the keeper if he is not on the alert to prevent or avoid this distinguished mark of its kindness." The edible swallow's nest is made of a secretion from the glands of a kind of swift; and many other birds are known to cast up secretions having individual peculiarities. Mr. Bartlett, continuing his observations, has found two other birds—the darter (*Plotus anhinga*) and the Brazilian cormorant (*Phalacrocorax Brazilianus*)—which throw up the inner linings of their stomachs, as do the hornbills.

Mode of Termination of Nerves in Muscle.—M. Foettinger has recently published a memoir on the mode in which nerves terminate in muscles. The muscles of insects were selected for observation in preference to those of other animals, because the details of their structure are more easily recognizable under the microscope than those of other groups of the animal king-

dom. The insects were placed in strong alcohol for some days, and the isolated fibers of the legs or trunk were examined with various powers. Each fiber or primitive fasciculus presents several nerve-endings, which are attached to the muscular fiber apparently without any definite rule as to their position or distribution. The muscular elements to which they are fixed are usually conical in form, a nerve running to the summit of each cone. The cone itself is composed of granular matter, with nuclei interspersed through it; and the granular matter is apparently sometimes obscurely segmented into portions surrounding each nucleus. The nerve-endings, or terminal plaques, as M. Foettinger calls them, are situated on the surface of the fiber, and their free surface is covered with a thin, structureless, transparent membrane, continuous with the sarcolemma of the muscular fiber on the one hand and the sheath of Schwann investing the nerve-fiber on the other. In insects contraction always begins in the muscular fiber at the plane of the cones, and at those points exclusively.

An Improved Smokeless Grate.—Dr. C. W. Siemens has recently proposed to remedy the smoke-nuisance, where it is due to the burning of bituminous coal in private houses, in a very simple way. Instead of burning such fuel in its crude state, in which the volatile and solid constituents are combined, he makes use of them after they have been industrially separated into the forms of coal-gas and coke. In these forms perfect combustion of both constituents is possible, and a smokeless and cleanly fire is produced at but little greater cost than with coal, and considerably less than gas alone. In order to burn the gas and coke together, Dr. Siemens has devised a simple and inexpensive modification of the ordinary grate, that can readily be made in any existing one. The construction consists in covering the bottom bars of a grate with a metal plate, which is bent to extend up the back, and in placing a gas-pipe along the lower front edge. This pipe is perforated on its upper side, the holes being a little inside of the middle line, so that the gas-flames incline slightly inward. The grate is filled with coke, which becomes incandescent upon its surface from the flame passing over it, and, as the interior of the mass is not heated, the maximum radiation from a given amount of fuel consumed is obtained. The coke has, of course, to be from time to time replenished, and the ashes removed, but in neither of these operations is there the trouble, or the dust and dirt, incident to the ordinary method of burning coal. Air is allowed to enter only in front, so that the mass of coke is protected from cooling drafts by the layer of hot gases. The heat of the bottom bars of the grate may be made to warm the air supplied to the gas, by a bent plate placed below, so as to form a chamber through which this air has to pass. Compared with the various forms of gas-grate, Dr. Siemens estimates that the cost for fuel is largely in favor of this. A thousand cubic feet of ordinary illuminating gas develops by its combustion 748,000 heat-units, and costs in London eighty-seven cents, while, to produce the same amount of heat by coke, fifty-six pounds are requisite, the cost of which is but eleven cents. Experiment has shown that, to heat a large room, eight feet of gas burned in this grate are sufficient, while fifty to seventy feet, Dr. Siemens states, are needed in a grate using gas only. Such grates could go into use very largely without any change in the present gas plant, as gas companies produce both the gas and the coke in about the proportions used, and this Dr. Siemens regards as an additional point in their favor.

Elevator Pneumonia.—The pulmonary diseases to which men employed in elevators are subject are described in an article by Dr. Thomas F. Rochester, published in the "Buffalo Medical and Surgical Journal." These men, who are generally Irish, of a nationality subject to affections of the lungs, work in gangs, shoveling in a close atmosphere which is teeming with dirt and dust and bearded particles of grain, often for thirty-six hours—sometimes, they assert (although the employers deny it), for six or seven days and nights at a time. They are liable to contract a disease which is known in the hospitals as *elevator pneumonia*. A new man, soon after he begins to work in the elevator, experiences catarrhal, nasal, and throat irritation; and, while he may

labor through a whole season with nothing more than this, he is liable to develop a subacute bronchitis, and occasionally a more dangerous affection. The morbific effects increase in the second and third years, and the shoveler will at last probably have to go to the hospital with a peculiar pulmonary disease, which may be of every grade and usually affects both lungs. The attack fixes him in the ward for at least three months, after which he may wholly recover if he goes into a new business, but, if he returns to his shoveling, he will soon fall a victim to lung-disease. A very few men continue to work in the elevators till they become old; and it appears that those who begin it at thirty-five or forty years of age bear it better than those who begin at twenty. Dr. Rochester considers a regulation and limitation of the hours of continuous labor, the sanitary regulation of lodging and boarding houses, and restriction in the use of ardent spirits, essential parts of any measures for checking this disease.

The Green Color of Oysters.—The fact that the green color of some oysters is caused by a variety of navicula, which is called *Navicula ostrearia*, is illustrated and established by experiments which have been recently made by M. Puységur, at Sissáble. A quantity of the green slime scraped from the edges of the "clears" was put, after the mud had been allowed to settle, into soup-plates. Perfectly white oysters, which had never been in the "clears," and the shells of which had previously been washed and brushed clean, were then put into the fluid. Other precisely similar oysters were put into plates of ordinary sea-water. In twenty-six hours after the beginning of the experiment, the oysters charged with diatoms had all acquired a marked greenish hue, while the other oysters remained unaltered. The experiment was repeated several times, with identical results; and the green color in the oysters was found to be more decided in proportion as the water was more highly charged with diatoms. The greenness disappeared on leaving the oyster for a few days in ordinary sea-water, to appear again when it was put in fresh water containing the navicula. It appears that the diatoms are drawn into the stomach of the oyster with the currents which it induces, and there part with their nutritive constituents. The chlorophyl is digested, and imparts its color to the blood, whence it happens that the most vesicular parts of the structure, as the bronchiæ, are most highly colored. The fact of the absorption of the diatoms was proved by the examination of the digestive tubes of the oysters experimented upon. Their stomachs, intestines, and exuviæ were strewed with carapaces of naviculæ.

Deep-Sea Explorations off the Coast of France.—A commission appointed by the Minister of Public Instruction in France has just accomplished an exploration of the depths of the Gulf of Gascony, and of a great submarine valley which lies parallel to the coast of Spain. The commission was composed of MM. Milne-Edwards, father and son, and several other naturalists, and Mr. Gwyn-Jeffreys and the Rev. Mr. Norman, of England. The expedition was completely successful, having collected at least five hundred species, nearly all of which are new to the fauna of the Gulf of Gascony, and some of which are new to science. Previous to this expedition, Messrs. Gwyn-Jeffreys and Norman had explored the fosse, or ditch, of Cape Breton, a curious submarine cavity in the sea-bottom of the department of the Landes, in which a connection was traced between the fauna of the Mediterranean Sea and of that part of the Gulf of Gascony.

M. Delaunay's Theory of Earthquakes.—M. J. Delaunay has proposed a theory that earthquakes, as well as many meteorological phenomena, are produced by the passage of the planets through the masses of meteors. The more severe seismic tempests, he believes, are caused by the passage of the larger planets through the cosmic groups, particularly through those in longitudes 135° and 265°, which appear to give rise to the August and November meteors. The passages of Venus, the Earth, and Mars through the groups seem to occasion only earthquakes of a secondary order; but each of these planets produces on its passage an increase of shocks in the months of August and November. The most violent and long-

est-continued convulsions, M. Delaunay suggests, take place when two large planets pass by the cosmic groups at the same time. Of this character were the earthquakes of 1755, 1783, 1829, and 1841. Accepting these principles as the laws regulating the occurrence of earthquakes, and admitting that certain of the cosmic groups may have a slow oscillatory motion around a mean position, it is not difficult to predict when earthquakes may be looked for. M. Delaunay ventures to predict the dates at which the earthquakes to occur between this time and 1920 will, according to his theory, be due. The most important earthquake periods will probably occur in the years and groups of years 1886, 1890–'91, 1898, 1900–'01, 1912–'13, 1914, 1919–'20. The next seismic tempest may be expected to follow the passage of Jupiter through the zone of the August meteors in 1883.

Do Stenches cause Disease?—The people of Paris were frequently annoyed during the last summer by the presence of mephitic odors in the atmosphere. A commission, appointed to discover the origin of the smells, traced them to certain establishments in the neighborhood where refuse matter is manufactured into fertilizers. M. Bouchardat, of the medical faculty of Paris, has examined the question of the effect of these emanations upon health, and has concluded that they are innocent. He does not believe that they convey with them the germs of disease, and finds that the gases of which they are composed do not load the air enough to produce a perceptible poisoning. Moreover, no injury to health has been traced to them. Assuming that contagious diseases should manifest themselves within eight or ten days after the germs have been planted, the weekly health bulletins of the year have been examined to learn if any increase of mortality followed the prevalence of the unpleasant odors. No such increase has been detected, but the mortality seems rather to have fallen off.

Mr. Thomson's Journey in Eastern Africa.—Mr. Keith Johnston was dispatched by the London Geographical Society, in 1878, with an exploring expedition to East Africa, charged with examining the country in the neighborhood of Lakes Tanganyika and Nyassa. Mr. Johnston died at Behobeho, just at the borders of the objective region of the expedition, on the 23d of June, 1879, and the whole responsibility of the undertaking fell upon Mr. Joseph Thomson, his geologist and general assistant, a young man twenty-two years of age, to whom this was almost the first serious experience in life. Mr. Thomson gave a most interesting account of the expedition, which was attended by unexampled success, at a meeting of the Society on the 8th of November last. His story is enlivened with accounts of different tribes of the most diversified characters and degrees of civilization, living by the side of one another. Leaving Behobeho on the 2d of July, the expedition went toward the west, into the country of the Wakhutu, passing through the valley of the Mgeta, where perennial showers precipitated from the high mountain-range on the right, which forms the ridge of the great central plateau of the continent, stimulate a tropical vegetation to grow and rot in marshy tracts. Under the influence of such an enervating and malarious climate, the Wakhutu are one of the most miserable and apathetic races to be found in Africa, and presented a disgusting sight to the traveler as they gathered around him in crowds, "sitting with their miserable, withered bodies doubled up, and idiotic, lack-luster gaze." Their neighbors, the Mahenge, a hitherto unheard-of tribe, living between the Ruaha and Uranga Rivers, were brought several years ago in contact with a migration of Zooloos, and have adopted the arms, dress, and manners of those people, although in other respects having no affinity with them. To the Wakhutu the Mahenge are a warlike and dreaded tribe; to the English traveler, "they were a set of most arrant cowards, a mean, sneaking, lying race, unworthy of the name of men." Ten days were occupied in crossing the mountain-ranges that bound the central plateau—a charming journey, with diversified scenery and luxuriant vegetation—after which the party entered upon a bleak, moorland country four or five thousand feet high, unrelieved by hill or dale or forest-tree. The scanty population of this barren district of Uhehe are settled in villages at very wide

intervals; "the people are a fine-looking race of gentlemen savages, who dress indifferently in nothing, or roll themselves into a winding-sheet of twelve yards of cotton." They treated their visitors courteously, "and always took indirect means of telling us anything unpleasant." Another plateau, from six to nine thousand feet high, extends around the north and east sides of Lake Nyassa, half-way to Lake Tanganyika and around Lake Hikwa, or Leopold, and is inhabited by three tribes in the lowest physical and mental condition, with whom it was almost impossible to communicate, as they seemed to be devoid of abstract ideas, and shut out from all knowledge and communication with the outside world. A short distance beyond the northwest corner of the beautiful Lake Nyassa, the expedition came to Makula's country, where the life and manners appeared of charming Arcadian simplicity. "The clean and ornamental villages would have adorned the neighborhood of any nobleman's park, and the richness of the soil was quite unrivaled"; and Mr. Thomson left, as he left no other place, with regret, a country which he had entered with apprehension. Thence the expedition passed through the country of the bold, rude, exceedingly inhospitable Wanyika; through Itawa, where Mr. Thomson was taken prisoner, and escaped by laughing at the excited warriors and being thought uncanny; and through other not very remarkable districts, to the "noble river Lukuga" and Lake Tanganyika. The Lukuga winds through a charming valley, with beautiful wooded hills rising on each side from its borders, adorned with forest clumps and open glades, where antelopes and buffaloes grazed in abundance. The river moved along in an exceedingly rapid current, full of cataracts, along which it roared and surged, making any attempt at navigation a matter of impossibility. Mr. Thomson would have followed it, but his men refused to go farther, and he turned back. He passed three weeks with the Warua, a very fine-looking race of men, living in the plain between the Lukuga and the Lualaba. They "are possessed of well-made figures, which the women adorn most artistically with tattooing. They wear a kilt made of the fibers of the Mwale palm, and dress their hair in the most elaborate fashion, the operation requiring two days' hard work. They are exceedingly ingenious in their carvings, and in every respect they are neat in their appearance and cleanly in their habits, but there all praise ends." They are arrant scoundrels and thieves, and one is not sure of his life among them for a moment. The feature of the return journey to Zanzibar most worthy of remark was the sight—the first to Europeans—from the highlands of Fipa, of the curious Lake Rukwa, Likwa, or Hikwa, to which Mr. Thomson took the liberty of giving a fourth name, Leopold. It is situated about four thousand feet above the sea, is surrounded by precipitous mountains about as much higher, and has no visible outlet. The people of the country are agriculturists, who do not join either in war or the chase; their chief is a king with absolute power, who lives on native beer, and is prevented by custom from wearing anything but a simple loin-cloth. Mr. Thomson reached Zanzibar in the spring of 1880. During his journey of a year in this most difficult country, he lost only one of the one hundred and fifty men with whom he started; and though often placed in critical positions, he never once had to fire a gun for either offensive or defensive purposes.

Artificial Production of Minerals.—M. Friedel gave an extended account, in a recent lecture at the Faculty of Medicine, Paris, of what has been accomplished in the artificial formation of minerals. The condition necessary to be fulfilled in this manufacture is that of obtaining crystalline products as nearly as possible identical in composition and appearance with the minerals to be reproduced. Generally experimenters have had to be satisfied with microscopic crystals; accepting these as sufficient, numbers of them have succeeded. Some have tried to imitate the processes of nature; others have reached their end by independent processes. M. de Senarmont, considering that the minerals in veins had been deposited from water charged with their constituents and flowing through the fissures of the rocks, with carbonic acid, sulphuretted hydrogen, and the alkaline sulphurets as solvents, and under suitable

conditions of temperature and pressure, obtained the sulphurets, oxides, and metallic salts he sought, with the bed-rock that held them. M. Daubrée has reproduced cassiterite, and several of the minerals that are found with it, by subjecting water and the right oxides to the action of chloric and fluoric vapors. MM. Fouqué and Michel Lévy, also following the indications of geological observation, have obtained the minerals of volcanic rocks in crystals, not only as isolated minerals, but also with the associations under which they form real rocks, resembling the natural rocks so closely as to deceive. Other processes have been employed, varying in their nature and operation according to the minerals which it was desired to produce, or the substances from which their production was sought. The number of minerals obtained by the different processes is so great that the mere enumeration of them all would be tedious. The most obvious and simple process is that of fusion. Some substances, among them the silicates, tend, when they cool from a liquid condition, to form amorphous glasses. Many of these, it has been found, will crystallize when heated again nearly up to the melting-point. By this process of sub-fusion several of the feldspars, oxide of iron, spinel, garnet, and other minerals have been obtained. When the substance does not melt readily, or is liable to decompose before melting, the process is aided by heating it with some suitable solvent. Thus have been obtained apatite, wolfram, tungstate of lead, pyrites, boracite, and other minerals. A considerable number of minerals may be crystallized from solutions in water of different temperatures. A curious feature of this process is that it operates sometimes to render a hydrate anhydrous. At other times the water may serve as a base to remove a portion of acid. It has been noticed also in this process that the crystals may be made larger by exposing them to repeated variations of temperature. Some minerals have been obtained from volatile solvents by vaporizing the solvents, when the minerals would be precipitated. Another process is by the action of two substances upon each other with or without the addition of electrical excitement, as when the oxide of copper is produced by the action of the solution of sulphate of copper and galena; another is by the reaction of vapors and gases on other bodies of similar nature or on solids—a process in which chlorine and the members of its group may play an important part.

M. Faye's Theory of the Solar System.—M. Faye, having pointed out in a former paper certain particulars in which the nebular hypothesis of Laplace fails to account for the movements of the planets, has published a second paper propounding a theory by which the retrograde movements of a part of the planets may be reconciled with the direct motions of the other planets, as results of the same laws. The theory of Laplace presupposes the existence of an immense degree of heat expanding the mass of the sun and its atmosphere to the extreme limits of the solar system, and a contraction by cooling, in the course of which planetary rings were thrown off by an excess of centrifugal force. M. Faye objects to the hypothesis of great heat as one of which there is no evidence; moreover, if the heat had existed and contraction had taken place by cooling, the outer atmosphere of the sun would have participated in the cooling and contraction so fully that it would have adhered to the mass, and no rings would have been thrown off. The new theory which he proposes in the stead of that of Laplace is based on the observation of the nebulæ, bodies which astronomers have often regarded as the points of departure for evolutions very different from those pictured by Laplace for evolutions tending to formations of the most varied character, as simple, double, triple, and quadruple suns, and globular aggregations of minute suns numbered by thousands. Would it not be natural, he asks, to accept the suggestion of these facts, the more so since our system belongs to the most common type—that of a nebula at first vague, then undergoing a central condensation, absorbing itself gradually and regularly into a nebulous star and finally into a solitary sun? Under this view, heat would no longer have to be invoked arbitrarily as an external agent; we would, on the other hand, see it gradually developed in certain points of the nebula, as the proper result of the energy

of every great dissemination of matter where the different members of the mass exercise a mutual attraction upon each other at a distance. M. Faye admits that in the transformation of the nebula rotatory movements would take place, and that trains of matter analogous to the rings of Saturn might be formed, and might break and give rise to planets. These formations, he believes, could be divided, according to their relations to the gravitation of the mass, between two zones, in the outer one of which the revolutions would, by the regular operation of the laws of gravity, be retrograde, while in the inner zone they would, under the same laws, be direct. This is shown to be possible by the following considerations: The density in the original nebula increases regularly from the periphery to the center, as appears actually in several nebulæ with which we are acquainted. It has been shown by calculation that the force of weight in a mass thus constituted increases, as we depart from the surface, in the inverse ratio of a power of the distance from the center. This progression, however, soon reaches a maximum, after which the weight is proportional simply to the distance itself, till at the center it is nothing. If we suppose planetary rings to be separated from a nebula of this nature, we may see that those separating from the external region will be of such a character that the motion of their outer circumference will be more rapid than that of their inner circumference, so that, when it is reduced to a globe turning upon itself, the globe will move in a retrograde direction. In the rings found in the second or inner region, on the other hand, the relative rapidity of the motion of the greater and lesser diameters will be reversed, and the rotation of the resultant globe will necessarily be direct.

Infertility in France.—The population of France has increased very slowly for several years. Among nineteen principal states of Europe, France stands the lowest in the rate of growth, having shown an annual increase of only 3·16 per thousand inhabitants from 1861 to 1869, while such countries as England, Norway, Scotland, and Russia, show an increase of from 12·94 to 13·85 per thousand. The rate of increase has fallen from six per thousand in 1770–'85, and has never since risen to that figure. The smallness of the excess of births over deaths, which is measured by the rate of increase, is due solely to the paucity of births; for the mortality has at no time been excessive, and has diminished steadily in the face of wars and epidemics, except during the German war, since the beginning of the century. It is not accompanied by a diminution in the number of marriages, for the proportion of marriages has not undergone any material variation during the century, and was higher in the sixth decade than in the first. Moreover, France outranks in the proportion of marriages to the whole population, and of marriages to the marriageable population, some of the states which greatly exceed it in the rate of increase of population. M. A. Legoyt has investigated the subject, and assigns the infertility thus shown to various moral, political, economical, and physiological causes. The decay of religious beliefs is a cause, the influence of which is shown in the tolerance given to the voluntary limitation of fertility, which is opposed by every religious system, and the increase of illegitimate unions, abortions, still-born, and infanticides. The unusually large proportion of persons who are just well enough off to be carefully provident is economically unfavorable to fertility. The popular opinion that poverty and children go together seems to be confirmed in France, where the poorer departments are the more fruitful ones. Other economical influences are the tendency of population to cities, the increasing expenses of living, and the system of dividing the paternal estate among all the children, which offers a standing temptation to the parent to have only a few children, so that each shall have as large a share as possible. The destruction caused by war operates powerfully to cut down the population. It is worse than pestilence, for it takes away the best and most vigorous. France has suffered much by wars during the last century, and has lost heavily at several periods, most notably during the two years of the German war, when the deaths considerably exceeded the births. The statistics of the recruiting officers show, however, that the vigor of the race has not

diminished, and that the mean length of life has been prolonged since 1815. Men and women marry at a later age than formerly, diminishing by several years the time during which they can have children, and, consequently, the number of children they can have. The host of women who are employed as nurses must suspend child-bearing while they are so employed. Young men are withdrawn from the possibility of marriage during their most vigorous age by the long period of military service; marriage itself is discouraged by the complicated and expensive processes the parties have to go through; and increasing alcoholism contracts the reproductive powers of both sexes.

Statistics of Suicide.—Professor Morselli, of Milan, in his "Étude de Statistique Morale" ("Study of Moral Statistics"), gives an analysis of the statistics of suicides in the countries of Europe, compiled from official reports, which reveals the important facts that the number of suicides is increasing, with only a few exceptions, in all European countries, and that it increases more rapidly than the population. The facts are set forth in a table showing the number of suicides in the several countries, in each of the seven periods of five years, from 1841–'45 to 1875. Except in the three Scandinavian states and the kingdom of Saxony, where there seems to have been a slight temporary decline, the table shows a progressive increase, and in all cases, except the four mentioned, the number of suicides is greatest for the last period, 1871–'75. Such statistics as Professor Morselli has been able to collect since 1875 show continued "enormous aggravations," particularly in Denmark, Finland, England, Belgium, France, Bavaria, the kingdom of Saxony, Prussia, Germany, Austria, Galicia, and Bukowina, the cantons of Neufchâtel and Geneva, and Italy. A comparison of the number of suicides in the latest period with the number at earlier periods shows an increase of 183 per cent. in Sweden since 1816; of 57·7 per cent. in England since 1836; of 322 per cent. in Prussia since 1816; of 308·8 per cent. in Austria since 1821; of 651·9 per cent. in Galicia and Bukowina since 1821; and a greater or less percentage of increase in other countries. A part of the increase is doubtless only apparent, and due to the greater perfection of the later statistical reports, but a great real increase remains to be accounted for. Professor Morselli arranges the influences which may predispose to suicides under the heads of cosmic and natural, ethnic, social, and individual. In the first class, climate, technical conditions, the phases of the moon, days, and hours, exert no perceptible influence, but an increase of suicides seems to accompany the monthly rise of temperature. The influence of race is not well defined, except, perhaps, feebly in the Germanic race. As for social influences, the inclination to suicide does not appear to be determined by the degree of civilization or of general instruction, by moral conditions (as to the prevalence of crime and natural births), nor by political and economical conditions. As for religion, Protestants seem as yet to kill themselves oftener than Roman Catholics, and still more frequently than Jews, in the countries where the three religions are represented in proportions of any importance. Density of population is without appreciable effect; but suicide is more frequent in cities than in the country. So far as individual influences are concerned, women kill themselves three or four times less frequently than do men; suicide increases with age to the extreme limit of life; marriage exerts a very marked preventive effect, while celibacy and widowhood favor suicide. Inquiries into the motives for suicide have not brought satisfactory answers, for it is hard to get the truth told about them, and official reports must be accepted with reserve. In France, higher, more generous motives are attributed to women than to men.

Mr. John Gould.—Mr. John Gould, F. R. S., an eminent British ornithologist, who died early in February, was born in September, 1804. The appointment of his father, as a foreman in the Royal Gardens at Windsor, gave him an opportunity of beginning the preparation for the work of his life by studying British birds in a state of nature. In 1827 he was appoint Curator to the Museum of the Zoological Society in London. Here he published, under the title of "A Century of

Birds from the Himalaya Mountains," the figures of a small collection of birds which were then rare and little known in Great Britain. He then undertook the "Birds of Europe," on a similar plan, which was finished, in five large folio volumes, in 1837. In 1838 he made extensive journeys in Australia and the neighboring islands, and collected specimens for the "Birds of Australia," a work which he gave to the public in seven folio volumes, in 1848, and which contained much that was new on the range and habits of sea-birds. The "Birds of Asia," "Mammals of Australia," and "Birds of Great Britain," which followed, were on the same comprehensive plan, and revealed the same thoroughness of preparation and accuracy in the representation of typical specimens as the previous works. Besides these great undertakings, Mr. Gould was the author of monographs on the toucans, the trogons, the humming-birds, the ant-thrushes of the Old World, the partridges of America, and the birds collected during the voyage of the Beagle by Mr. Darwin, for all of which, as well as for the larger works, he prepared the original designs, from which the splendid colored plates—constituting "the most beautiful series of pictures of animal life which have yet been produced"—were executed.

The New Mineral, Peckhamite.—Professor J. Lawrence Smith has found a new meteoric mineral in the analysis of the great meteorite which fell in Emmett County, Iowa, in May, 1879, and has named it Peckhamite. He describes it as decidedly different from any mineral he has seen associated with meteorites. It is a silicate of iron and magnesia, opalescent, of a light greenish-yellow color, of greasy aspect, and cleaves readily. In two or three specimens the mineral projected from the outer surface of the stone, with a dingy-yellow color and a fused exterior. It differs widely in structure from olivine, which was abundant in the stone. Professor Smith states, as an additional fact concerning the meteorite, that its fall was attended by a shower of fragments like hailstones, of which several thousand, varying from the size of a pea to five hundred grammes in weight, have been picked up. All the smaller pieces are lumps of nickeliferous iron, and even the larger ones have but little stony material attached. They lay on the wet prairie for nearly a year, and are yet not at all rusted; many parts are still bright, and some look like nuggets of platinum.

Quarantine and Systematic Medical Inspection.—The "Lancet" denies that there is any value in the ordinary practice of quarantine. The reasoning on which the system is founded is plausible and seductive, but it is impossible to make it practically efficient. Contraband — the secret escape of infected persons and goods through the lines—is one of its commonest accompaniments, and most often defeats its purpose. "Moreover, in all great extensions of disease, the initial extension has generally occurred before the danger was anticipated, and the imposition of quarantine has taken place after the mischief which it was designed to avert had been accomplished." Quarantine is generally credited with having prevented the extension of the recent plague from the Volga to Europe, but wrongly; though enforced, it did not prevent the conveyance of the pest from Persia to Russia; and it had no effect upon the transmission of the disease from the Volga, for the plague had practically ceased to prevail before any measure of quarantine was adopted. It has been, in fact, an evil, both on account of its futility and because it has diverted attention from a true means of preventing infectious disease. "In so far as it may have contributed to a clearer knowledge of the conditions under which the isolation of persons and things is desirable and may be advantageous, and of the hygiene of ships and of masses of persons, such as pilgrims and emigrants, journeying both by sea and by land, quarantine may indirectly have yielded certain advantages, but advantages wholly disproportionate to the cost at which they have been gained, and which were attainable in a much simpler and more effective fashion." England and Denmark have ceased to rely upon quarantine as a protection against infection, though they still keep up the forms in order to obviate disabilities that would be imposed on their shipping by other governments which adhere to the practice. The system of medical inspection

and the general sanitary administration take its place in England. The sanitary administration is so devised that every district, whether inland or on the coast, is enabled to deal with infectious disease, coming from whatever source, in the most efficacious manner. The sanitary authorities of the ports are, moreover, given power to inspect medically persons arriving in ships from infected places, remove and isolate the sick, and use whatever processes of disinfection may be deemed necessary. Experience has shown that this system "does all that the most efficient quarantine can be hoped to do, and that more effectually, without involving those grave hardships to individuals and interruptions and disturbances to commerce which have arisen and must arise from quarantine."

Retreat of Glaciers.—M. Charles Dufour read a paper on the retreat of glaciers, at the recent meeting of the French Association for the Advancement of Science. His observations of the phenomena were begun in 1870, while he was sojourning by the glacier of the Rhône for the purpose of measuring the amount of the condensation of vapor on the ice. In connection with Professor Forel, he made a chart of the front of the glacier, as it was defined by reference to marks fixed in the moraine. The comparisons for the revision of the chart from year to year established the fact that the glacier was constantly receding. According to the statements of the inhabitants of the country, the retreat began in 1855 or 1856, and it now exceeds all that has been otherwise certainly determined within historical times. This phenomenon is not peculiar to the glacier of the Rhône. All of the glaciers of the Alps have begun to recede at some time more or less distant, and some of them have even disappeared. The same is the case with the glaciers of the Pyrenees and the Caucasus. Information is still wanting with reference to the glaciers of the Scandinavian Alps. A general retreat of so much importance as appears to be shown can hardly be explained by a theory of casual modifications of climate.

American Storms in Europe.—M. Hébert communicated to the French Association for the Advancement of Science the results of an investigation which he had made, day by day, during six months of winter, of the meteorological phenomena of North America from Greenland to Colombia and Venezuela. He traced the formation, along the grand mountainous crest of the continent and on its eastern slope, of powerful phenomena of sirocco, which dried the continent and limited its vegetation. He followed the rotatory storms which are produced on these crests step by step across the continent and the adjacent seas and to the western coasts of Europe. These storms, which are much more powerful than those which he has investigated in Europe, have otherwise, but with much more intensity, the same characters with them, and are the source of the depressions and tempests which are experienced in Europe. The storms which reach the European coast originate for the most part in Mexico, Central America, and the northern parts of South America; but they do not generally strike the Atlantic till after they have traversed a more or less extended part of the length of the North American Continent. The storms which originate in the United States reach Greenland, or pass the neighborhood of Iceland or the Faroe Islands, too far away to affect Europe.

Carbonic Acid in the Sea.—In communicating his studies on the proportion of carbonic acid in the air, M. Schloesing remarks that some of the causes which regulate the production and consumption of this substance are subject to considerable and relatively rapid variations; such are vegetation and the slow combustion of organic residua, the activity of which depends on the temperature. But, besides the fact that these variations take place in an inverse degree in the different regions of the globe, and therefore partly balance one another, there exists a powerful regulator of them, which combines its action with that of the circulation and the commingling operation of the atmosphere: it is the sea. Acting upon this idea, M. Schloesing has calculated the quantity of carbonic acid concealed in the seas, and has arrived at the conclusion that the sea holds in reserve a quantity of acid available for exchange with the atmosphere ten times greater than the whole quantity

contained in the atmosphere, and, *a fortiori*, much greater than the variations in that quantity. Although the figures can not be absolutely correct, we may certainly conclude that the sea is much richer in disposable carbonic acid than the atmosphere, and is in good condition to play the part of a regulator of the supply.

NOTES.

A TWO months' course of instruction in plumbing and sanitary engineering was opened on the 16th of February, in connection with the Technical Schools of the Metropolitan Museum of Art in this city. The lectures on the chemical side of the course are delivered by Professor C. F. Chandler, those on plumbling by Mr. C. F. Wingate. The enrollment at the earlier meetings of the class was unexpectedly large, and indicated the existence of a lively and wholesome interest in the subject.

SEVERAL papers of much interest were read at the second annual meeting of the Natural History Society of Illinois, held February 8th. Professor S. A. Forbes discussed the "Illustrations and Applications of Evolution," with especial reference to the restocking of our waters with their native species of fish. He showed that the idea that fishes could be artificially multiplied in such numbers that it would make no difference how, or where, or in what numbers they were caught, involved a contradiction of the doctrine of natural selection. The food-supply of fishes was diminished by the drainage of swamps, the restriction of overflows by levees, and by other operations attendant upon the settlement of a country; and it was not to be expected that the fishes in a body of water could be permanently kept up to as high a number as flourished before the natural conditions were changed.

STEPS have been taken in this city to provide the necessary organizations to furnish facilities for cremation. A draft of a charter has been approved by the persons concerned in the movement, for the formation of "the United States Cremation Company (limited)," with a capital of fifty thousand dollars, whose peculiar object shall be "to cremate the human dead in the quickest, best, and most economical manner." A plan has also been adopted for the formation of the "New York Cremation Society," as an association distinct from the purely business enterprise, having for its object "to disseminate sound and enlightened views respecting incineration as preferable to burial, and to advance the public good by offering facilities for cremation."

PROFESSOR DR. EMANUEL BORICKY, a Bohemian mineralogist, who died January 27th, aged forty years, was best known by his microscopical researches in petrography. He had been connected with the Bohemian Museum and the University and colleges of Prague since 1865, and since 1871 had lectured in the Bohemian language on petrography at the University of Prague. He has left a monograph on the porphyries ready for the press.

MR. WILLIAM P. BLAKE describes, in the March number of the "American Journal of Science," the beds of realgar and orpiment in the sedimentary formations underlying the lava in Iron County, Utah. These arsenical sulphides are found in lenticular and nodular masses, in a layer about two inches thick, in a compact, sandy clay. Above and below the layer and close to it are thin parallel seams of fibrous gypsum, while the strata above, for thirty feet or more, are arenaceous clays charged with soluble salts which exude and effloresce, forming hard crusts. The whole appearance and association of the minerals indicate that they have been formed by aqueous infiltration since the deposition of the beds. Beds of stibnite, or antimony sulphide, in the same formation, had probably a similar origin.

CHARLES F. KUHLMANN, a distinguished Alsatian chemist and economist, whose death has recently been announced, had been for the last forty years a prominent figure in the industrial and scientific circles of France, and was known as the founder at Lille of one of the most important chemical manufactories of the world. His name is also associated with investigations which have had valuable results on the baryta compounds, the crystallization of insoluble bodies, on the manufacture of sugar, on the chemistry of mortars and manures, bleaching, dyeing, and printing, and on many subjects of a more purely scientific character. His collected researches were published in 1879 in a single large volume.

MERCADIER has described a new and economical method of producing intermittent luminous signals by burning petroleum with oxygen. He has a lamp with a round wick, within which is a tube rising not quite up to the level of the top of the wick. This tube reaches a reservoir of oxygen: when the lamp is lighted and a properly adjusted jet of oxygen is permitted to reach it, it gives out a white flame, the intensity of which approaches that of the oxyhydrogen light. When the lamp is burned without oxygen, it gives a smoky flame of little brilliancy, which will, however, rapidly increase in intensity, and soon reach a maximum when the oxygen is turned on.

M. Pasteur has reported concerning experiments on the endurance of vitality in the germs of disease. Seven sheep were led daily, for a few hours, to a piece of ground where some animals that had died of anthracoid disease, or *charbon*, had been buried twelve years previously. Two of the sheep caught the disease and died. As there was no grass on the spot for the animals to eat, M. Pasteur believes that they must have received the germs of the malady from smelling about the ground, as sheep are in the habit of doing.

Mr. William White, author of several works on subjects of chemistry and mining, died in London, January 29th, at the age of seventy-one. He had held at different periods lectureships on metallurgy and chemistry at various educational establishments, and had been a constant contributor to scientific literature for more than half a century.

The council of the Society of Arts has offered for its third Congress on Domestic Economy, which is to be held during the present year, prizes for papers not exceeding one thousand words each, written by teachers, and giving accounts of the best methods practiced by them, of their experience, and of the results of their teaching on the subjects of clothing and washing; the dwelling—warming, cleaning, and ventilation; rules for health, including the management of the sick-room, cottage income, expenditure, and savings; food, its composition and nutritive value, its functions, its preparation and culinary treatment. The papers are to be sent in to the secretary of the Society, London, by the first of May next.

A course of twenty-five lectures, for practical instruction in invertebrate paleontology, was opened in Philadelphia, March 8th, by Professor Angelo Heilprin, under the auspices of the Academy of Natural Sciences of that city. The plan of instruction embraces the examination of the life-histories of the various geological formations, the discussion of the biological relations of past organic forms, and the practical determination of those forms for the purposes of paleontological inquiry. A course of ten lectures for practical instruction in determinative mineralogy was begun by Professor H. Carvill Lewis, March 15th.

Whales were formerly counted as important aids to the fisheries of the North Sea coasts, by driving immense numbers of small fishes toward the land. Now, according to M. Bogdanoff, of the recent Russian North Sea expedition, since the whales have been pursued with steamers and bullets instead of sailing-vessels and the old harpoon, their destruction has greatly increased, and the number of small fish coming to the coast has correspondingly diminished. The cod-fishing has been nearly extinguished in parts of the Varanger Fiord region in consequence of the presence of sharks, which, attracted by the fat thrown into the sea at Varanger, destroy the fish. Both of these instances illustrate the interdependence which exists among the different kinds of animals inhabiting the same region.

Professor Du Bois-Reymond, in conjunction with Professor G. Fritsch, is about to publish, under the auspices of the Royal Academy of Sciences at Berlin, the observations and experiments made by the late Dr. Karl Sachs on the electrical eel (*Gymnotus electricus*), in South America, during 1876 and 1877.

M. Gréhaut has been endeavoring to determine by experiment what proportion of carbonic oxide in the atmosphere is necessary as a minimum to produce the death of animals. With a dog the proportion varied from $\frac{1}{300}$ to $\frac{1}{250}$; a hare was not asphyxiated till it had been exposed to an atmosphere containing $\frac{1}{60}$ of carbonic oxide; a sparrow was killed by confinement in an atmosphere charged with only $\frac{1}{800}$ of the gas. A very wide range of difference is thus shown to exist in the susceptibility of different species to this poison.

Professor Adolphe Brongniart was engaged at the time of his death in the study of the silicified seeds of the carboniferous beds of St. Etienne and Autun, France. His investigations have been published by some of his family. Among the results was the discovery in fossil seeds of a pollen-bearing chamber hitherto unknown in any living plant, in which the pollen was held in reserve till the time of fecundation. M. Brongniart, remarking that the palæozoic plants exhibiting this disposition were related to the cycades, believed that the modern cycas might also possess it, and found his belief confirmed by an examination of plants of that genus. This is said to be the first time that paleontological studies have led to an anatomical discovery in living beings.

Dr. John Jeremiah Bigsby, F. R. S., a well-known writer on palæozoic fossils, died in London, February 10th, at the advanced age of eighty-eight years. The greater part of his life was spent in Canada and the United States. He contributed a paper on a subject of American geology to "Silliman's Journal," as far back as 1820. His best-known works are two "Thesauri," relating to the flora and fauna of the Silurian and the Devonian and Carboniferous formations, which were published in 1868 and 1878. He was the founder of the Bigsby medal, which is awarded at the annual meetings of the Geological Society of London.

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